



Subject card

Subject name and code	SUSTAINABLE MATERIALS AND ENERGY MANAGEMENT, PG_00064504						
Field of study	Chemistry						
Date of commencement of studies	October 2024		Academic year of realisation of subject		2026/2027		
Education level	first-cycle studies		Subject group		Optional subject group Humanistic-social subject group Subject group related to scientific research in the field of study		
Mode of study	Full-time studies		Mode of delivery		at the university		
Year of study	3		Language of instruction		Polish		
Semester of study	6		ECTS credits		4.0		
Learning profile	general academic profile		Assessment form		assessment		
Conducting unit	Department of Energy Conversion and Storage -> Faculty of Chemistry -> Faculties of Gdańsk University of Technology						
Name and surname of lecturer (lecturers)	Subject supervisor		dr hab. inż. Monika Wilamowska-Zawłocka				
	Teachers						
Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	15.0	0.0	15.0	15.0	0.0	45
	E-learning hours included: 0.0						
Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan		Participation in consultation hours		Self-study	SUM
	Number of study hours	45		5.0		55.0	105
Subject objectives	The course aims to provide students with comprehensive knowledge of sustainable materials synthesis and advanced recycling technologies, with a focus on both material and energy recovery aspects. Students will become familiar with current trends in the development of materials that minimize the use of critical raw materials, as well as opportunities for utilizing secondary raw materials obtained through recycling. The course equips students with the skills required to plan, design, and analyze recycling processes, while fostering an understanding of the broader context of sustainable development and the role of technology in environmental protection.						

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[K6_U05] designs and performs experiments to confirm a hypothesis, recognises the wider, often non-technical context of the phenomena analysed	analyzes and evaluates material and energy recovery processes, plans and conducts experiments and project tasks, interprets the obtained results, and takes into account the environmental, economic, and social aspects of the solutions under consideration.	[SU3] Assessment of ability to use knowledge gained from the subject [SU4] Assessment of ability to use methods and tools
	[K6_K02] is aware of the importance of non-technical aspects and consequences of engineering activities, including their impact on the environment, and of the related responsibility for the decisions to be taken	recognizes the impact of decisions related to materials and energy management on the environment and society, understands the professional responsibility of engineers, and incorporates the principles of sustainable development into technical and organizational decision-making.	[SK1] Assessment of group work skills [SK5] Assessment of ability to solve problems that arise in practice
	[K6_W04] identifies the conditions of chemical processes occurring in the analysed systems through the appropriate selection of methods to solve them, by taking into account the interdependence of the structure and properties of key materials in sustainable development technologies	has the necessary knowledge to characterize processes related to materials and energy management and identifies relationships between the structure, properties, and potential applications of materials in technologies supporting sustainable development, including recycling and raw material recovery processes.	[SW1] Assessment of factual knowledge [SW3] Assessment of knowledge contained in written work and projects
	[K6_U09] is able to recognise hazards, counteract them and work with chemical reagents and basic technical apparatus in accordance with health and safety principles and the concept of sustainability	applies health and safety regulations during laboratory activities related to material recycling and resource recovery, correctly operates laboratory equipment, and follows the principles of sustainable resource management.	[SU2] Assessment of ability to analyse information [SU3] Assessment of ability to use knowledge gained from the subject [SU4] Assessment of ability to use methods and tools

Subject contents	Course content – lecture		
	The lectures cover topics related to materials and energy management in the context of sustainable development, resource efficiency, and the circular economy. The introductory part presents the fundamental concepts of recycling, material and energy recovery, resource management, the importance of critical raw materials, and legal regulations related to materials and energy management. The next part of the course focuses on modern approaches to managing material flows. Technologies for waste sorting and processing, as well as recycling methods for plastics, metals, glass, and cellulosic materials, are discussed. The course also addresses the principles of designing recycling processes in accordance with sustainable development requirements, together with methods for the recovery and reuse of critical raw materials. In the area of energy management, the course presents technologies for energy recovery from waste and biomass, fundamental thermal and chemical energy conversion processes, and issues related to the energy efficiency of industrial operations. The impact of material and energy recovery on reducing the consumption of natural resources and greenhouse gas emissions is also analyzed. An important part of the lectures is devoted to sustainable materials design and synthesis, including the use of secondary raw materials, strategies for reducing the consumption of critical raw materials, and the design of materials with consideration for their future recyclability. The fundamentals of green chemistry and green engineering are also introduced. The final part of the course addresses the economic, environmental, and social aspects of materials and energy management, circular economy business models, the application of Life Cycle Assessment (LCA), and the influence of consumer awareness on the development of sustainable technologies and contemporary market trends.		
	Course content – laboratory		
	Laboratory classes focus on the practical aspects of material resource management through the recovery and reuse of raw materials obtained from technological waste streams. Particular attention is devoted to lithium-ion batteries as an important source of valuable materials used in modern energy technologies. During the laboratory sessions, students become familiar with methods for preparing spent batteries for material recovery processes, techniques for separating individual components, and approaches for evaluating the quality of recovered products. Selected stages of direct recycling, hydrometallurgical recycling, and pyrometallurgical recycling are presented and performed, enabling the recovery of active materials and critical raw materials. The laboratories also address the recovery of graphite and metals used in battery electrode materials, their purification, and physicochemical characterization. Students assess the efficiency of recovery processes and investigate opportunities for incorporating recovered materials into subsequent production cycles. An important component of the laboratory work is the use of recycled materials in the preparation of new electrochemical cell components. The results obtained provide a basis for evaluating material management efficiency and the environmental benefits associated with closing material loops within a circular economy framework.		
	Course content – project		
	Project classes are dedicated to the environmental assessment of materials and technologies using the Life Cycle Assessment (LCA) methodology. Students carry out projects focused on selected materials used in modern industry and society, evaluating their impact on resource consumption, energy demand, and environmental performance throughout different stages of their life cycle. Projects are conducted in a computer laboratory using professional LCA software and specialized environmental databases. Students develop life cycle models, define system boundaries, analyze process data, and determine environmental indicators for selected material solutions. The projects include comparisons of different raw material sourcing strategies, the use of recycled materials, and alternative end-of-life management scenarios. Particular emphasis is placed on assessing the benefits of material and energy recovery as well as improving resource-use efficiency. The final outcome of the project is a comprehensive report presenting the environmental assessment of a selected material or product, together with recommendations for improving material and energy efficiency in accordance with the principles of sustainable development and the circular economy.		
	Prerequisites and co-requisites		
	Knowledge of the basics of inorganic and organic chemistry. Basic knowledge of mathematics.		
Assessment methods and criteria			
	Subject passing criteria	Passing threshold	Percentage of the final grade
	Lectures - exam	60.0%	40.0%
	Laboratories - report	60.0%	30.0%
	Project - finished project task	60.0%	30.0%

Recommended reading	Basic literature	1) N. J. Themelis, Recovery of Materials and Energy from Urban Waste, in R. A. Meyers (ed.), Encyclopedia of Sustainability Science and Technology, Springer Science+Business Media LLC, part of Springer Nature 2018 2) S. K. Ghosh, Energy Recovery Processes from Wastes, Springer Verlag, Singapore, 2020 3) C. Hubert, Handbook of Recycling Technology, Syrawood Publishing House, 2019 4) A. K. Błędzki, R. Jeziórska, J. Kijeński, Odzysk i recykling materiałów polimerowych, Wydawnictwo Naukowe PWN, Warszawa 2021 5) E. Klugmann-Radziemska, J. T. Haponiuk, J. Datta, K. Formela, M. Sienkiewicz, M. Włoch, Nowoczesne technologie recyklingu materiałowego, Wydawnictwo Politechniki Gdańskiej, Gdańsk 2017 6) T. Georgi-Maschler et al., Development of a recycling process for Li-ion batteries J. Power Sources 207 (2012) 173–182. 7) Odpady niebezpieczne. Przepisy i codzienność, Wiktoria Sobczyk, Wydawnictwo AGH, Kraków, 2019 8) Gospodarka odpadami niebezpiecznymi pod redakcją Krystyny Mędzyckiej, Wydział Chemiczny Politechniki Gdańskiej, 1996
	Supplementary literature	1) Basic hazardous waste management, William C. Blackman Jr., Lewis Publishers, New York, 2001 2) G. Harper et al., Recycling lithium-ion batteries from electric vehicles, Nature volume 575 (2019) 75–86. 3) I. A. Ignatyev et al., Recycling of Polymers: A Review, Chem. Sus. Chem, 7 (2014) 1579-1593. 4) O. Dogu et al., The chemistry of chemical recycling of solid plastic waste via pyrolysis and gasification: State-of-the-art, challenges, and future directions, Progress in Energy and Combustion Science, 84 (2021) 100901.
	eResources addresses	
Example issues/ example questions/ tasks being completed	1) Discuss the importance of critical raw materials for the modern economy and the energy transition. 2) Discuss recycling technologies and their role in sustainable resource management. 3) Explain the main stages of direct, hydrometallurgical, and pyrometallurgical recycling of lithium-ion batteries. 4) Identify the principles of materials design that facilitate future recycling and resource recovery. 5) Compare the environmental impacts of using primary and secondary raw materials for a selected material.	
Practical activities within the subject	Not applicable	

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