COURSE DESCRIPTION CARD - SYLLABUS

Course name
Energy recovery [S2TOZ1-TSO>OE]

Course

Field of study
Circular System Technologies

Year/Semester
2/3

Area of study (specialization)
Renewable raw material technologies

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
0

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

1,00

Coordinators

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Lecturers

Prerequisites

The student starting the course: has basic knowledge of physics, chemistry, chemical engineering, and the construction of process apparatus, acquired during the 1st and 2nd degree classes, enabling understanding and interpretation of phenomena and processes occurring during the discussed processing operations; is able to acquire and supplement information from academic textbooks and other books; has the ability to self-study; understands the need for continuous training and setting ambitious goals on the way to higher education.

Course objective

The objective of this lecture is to present energy recovery systems, with a focus on waste incineration technologies and their application in extracting energy from various waste streams (municipal, industrial, special). The main focus is on the technical aspect of the processes discussed, environmental controls and legal conditions governing the operation of waste-to-energy systems, highlighting current practices and emerging innovations in the field.

Course-related learning outcomes

Knowledge:

K_W05 Demonstrates a comprehensive and theoretically informed understanding of contemporary environmentally sustainable technologies.
K_W06 Demonstrates comprehensive knowledge of the factors that pose a threat to the environment and is conversant with the principles of waste neutralization and recovery, taking into account the requirements of a circular economy.
K_W12 Exhibits a profound understanding of the methods of material recycling, raw material and energy recovery from waste materials, which are essential for the design, optimization and implementation of innovative technological processes.
K_W15 Demonstrates a comprehensive understanding of technological process control, including an appreciation of the rationale behind process control and the resulting benefits for technologies related to a circular economy and the environment.

Skills:
K_U10: Demonstrate the ability to select methods of recycling, chemical recovery, and disposal of various wastes, as well as to formulate the assumptions necessary to design innovative solutions based on the principles of a circular economy.
K_U13: Demonstrates the ability to assess the quality of reprocessed waste materials and to qualify them for further use in various industries.
K_U16: Is capable of analyzing and critically evaluating new areas in closed-loop technologies and related fields, assessing their innovativeness and technical feasibility.

Social competences:
K_K01 Demonstrates an understanding of the personal responsibility that arises from his professional role and the emergence of moral and ethical issues in the context of professional activities.
K_K02 demonstrates an understanding of the necessity to disseminate knowledge regarding sustainable production and technological solutions in a circular economy.
K_K03 Critically evaluate own knowledge, recognize the necessity for further education, and enhance their professional, personal, and social competencies.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The grade for the lectures is determined by the result of a written pass implemented in the form of open questions or a test. The open form of the pass will include at least 3 descriptive questions. The test will consist of at least 40 questions of various types (single/multiple choice, completion, enumeration, marking on a drawing/scheme, simple calculus task, etc.). Credit will be graded with a scale: 51%-60% (3,0), 61%-70% (3,5); 71%-80% (4,0), 81%-90% (4,5), 91%-100% (5,0).

Programme content

This lecture presents the concepts of energy recovery, waste-to-energy (WtE) systems, and waste incineration technologies. It begins by introducing energy recovery methods, focusing on both incineration and broader applications like waste heat recovery. Then lecture delves into the principles and processes of waste incineration, explaining how energy is extracted from municipal, industrial, and other waste streams including biomass, medical, sewage, and animal waste. The waste are discussed in terms of their incineration potential and environmental impacts. The lecture presents various incineration installations and characterizes the thermal waste treatment plants existing in Poland. It also covers the regulatory landscape governing waste incineration, with a particular focus on the European Union and Poland, while comparing these standards to those in the U.S. and Asia. Finally, it conclude with a look at future trends in waste management, emphasizing innovations in technology aimed at improving energy recovery and sustainability practices.

Course topics

The lecture offers a comprehensive overview of energy recovery and waste incineration, introducing a variety of methods for converting waste into usable energy. It begins by explaining how energy recovery is integral to sustainable waste management, not only through incineration but also through other technologies for example waste heat recovery from industrial processes. The lecture describes the working principles of waste-to-energy systems, demonstrating how incinerators transform municipal and industrial waste into electricity and heat. It highlights the environmental and technological

challenges involved, particularly in handling biomass, medical, sewage, and animal waste, each of which presents unique requirements for incineration and emission control. Throughout the lecture, students will gain insight into the environmental implications of waste incineration, such as greenhouse gas emissions, dioxins, and particulates, and how modern technologies mitigate these impacts. The regulatory framework is another key topic, with a focus on the European Union’s standards for emissions and waste handling, Poland’s approach to waste management within this framework, and comparisons with the U.S. and Asia, which have varying degrees of regulatory enforcement and technological advancement. The final lectures cover the future of energy recovery, exploring innovations such as pyrolysis, plasma gasification, carbon capture, and circular economy initiatives aimed at reducing the volume of waste requiring incineration. These emerging trends signal a shift toward more efficient, environmentally friendly waste-to-energy systems that align with global sustainability goals.

Teaching methods

Multimedia presentation supported by examples presented on the board.

Bibliography

Basic:
Grzegorz Wielgosiński (2020) Termiczne przekształcanie odpadów. Wyd. Nowa Energia (Racibórz), ISBN: 978-83-928582-5-6
Tomasz Józef Jaworski (2023) Termiczne przekształcanie odpadów w aspekcie gospodarki obiegu zamkniętego, odnawialnych źródeł energii oraz energetyki. Wyd. Politechniki Śląskiej (Gliwice), ISBN: 978-83-7880-934-0
Marian Rosiński (2012) Odzyskiwanie ciepła w wybranych technologiach inżynierii środowiska. Wyd. 2 popr. Oficyna Wydawnicza Politechniki Warszawskiej (Warszawa), ISBN: 978-83-7814-011-5

Additional:
Andrzej Jędrczak (2007) Biologiczne przetwarzanie odpadów. Wyd. Naukowe PWN (Warszawa), ISBN: 978-83-01-15166-9
Janusz W. Wandrasz, Andrzej J. Wandrasz (2006) Paliwa formowane: biopaliwa i paliwa z odpadów w procesach termicznych. Wyd. "Seidel-Przywecki" (Warszawa), ISBN: 83-919449-7-2
Danuta Joanna Król (2013) Biomasa i paliwa formowane z odpadów w niskoemisyjnych technologiach spalania. Wyd. Politechniki Śląskiej (Gliwice), ISBN: 978-83-7880-010-1

Breakdown of average student's workload

	Hours	ECTS
Total workload	25	1,00
Classes requiring direct contact with the teacher	15	0,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	10	0,50