Syllabus
Course Program

Bio-Power Engineering Complexes

Specialty
141 – Electric Power, Electrical Engineering and Electromechanics

Institute
Institute of Education and Science in Power Engineering, Electronics and Electromechanics

Educational program
Electric Power Industry

Department
Engineering Electrophysics (135)

Level of education
Bachelor's level

Course type
Special (professional)

Semester
8

Language of instruction
English

Lecturers and course developers

Mykyta Petrenko

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Ph. D., Associate Professor at the Engineering Electrophysics Department of NTU "KhPI".
Authored 6 publications in the domain of strong magnetic field calculations, computation of strong magnetic fields, electromagnetic forming and related areas. Lecturer on “Modelling of Electro-Physical and Electric Power Equipment and Processes”, “High Voltage Measurements”, “High Voltage Equipment”, “High Voltage Pulse Equipment”, etc.
More about the lecturer on the department's website

General information

Summary

The "Bio-Power Engineering Complexes" course provides an extensive understanding of the vital role biomass plays in the renewable energy sector. Beginning with foundational concepts, the course explores the nature and origins of biomass, underscoring the advantages of renewable energy and the pitfalls of conventional energy sources. A focal point of this elucidation is the carbon cycle, shedding light on the excess carbon release resulting from fossil fuel combustion.
Delving deeper into the subject, the course illuminates various methods of energy extraction from biomass. These range from direct incineration, with its diverse modalities such as using raw biomass or processed forms like pellets, to more intricate methods involving bio-fuels. Notably, bio-diesel and biogas receive considerable attention. The course delves into the anatomy of biogas, placing emphasis on its production process, especially anaerobic digestion. Highlighting its natural occurrence, students will grasp the environmental implications of methane release, especially in agricultural contexts.
Further enriching the curriculum, a segment is dedicated to the practical elements of bio-power engineering. Students will become acquainted with the diverse types of digestion tanks, equipment vital for mixing, heating, and other associated operations intrinsic to the bio-energy production cycle.

Course objectives and goals

The primary objective of this course is to impart a comprehensive understanding of contemporary bio-power engineering complexes and the nuances of biomass conversion into fuel. By the culmination of the course, students will acquire in-depth knowledge of modern bio-power engineering systems and their operational principles, gain proficiency in biomass conversion technologies and the associated equipment

and processes, understand the different facets of bio-energy extraction methods, with special emphasis on bio-diesel and biogas, recognize the environmental implications of various bio-energy production methods, especially the significance of methane release, stay abreast with current trends and advancements in bio-energy production setups.
Converging theory with practical knowledge, this course is meticulously designed to produce well-rounded individuals adept at navigating the intricate landscape of bio-energy. Through rigorous instruction and hands-on experience, students are set on a trajectory to become invaluable assets in the rapidly evolving realm of renewable energy.

Format of classes

Lectures, workshops, consultations, self-study. Final control in the form of module tests.

Competencies

GC 3. The ability to apply knowledge in practical situations
GC 7. Skills of using information and communication technologies.
GC 8. The ability to learn and master modern knowledge.
GC 14. Ability to demonstrate basic knowledge in the field of natural sciences and readiness to use the methods of fundamental sciences for solving general engineering and professional problems.
PC 3. Ability to use basic knowledge of general physics, higher mathematics, theoretical foundations of electrical engineering and electrical materials for solving practical problems in the field of electric power engineering, electrical engineering and electromechanics.
PC 11. Ability to observe the requirements of the rules of safety and occupational safety and norms of industrial sanitation when working at the enterprises of electrical and electromechanical complexes.
PC 12. Ability to study and analyze scientific and technical information in the field of electric power engineering, electrical engineering and electromechanics.
PC 15. Understanding the principles of organizing electricity generation processes based on traditional and renewable energy sources, meeting the specified technological parameters of power plants and the quality of electricity.

Learning outcomes

PRT 2. Discuss professional topics
PRT 12. Know and use the methods of fundamental sciences to solve the general engineering and professional tasks.
PRT 16. To define principles of construction and normal functioning of elements of electric power, electrotechnical, electromechanical complexes and systems.
PRT 18. To evaluate the parameters of the electrical, electrical and electromechanical equipment and related complexes and systems work and to develop measures to increase their energy efficiency and reliability.
PRT 19. Solving professional tasks in the design, installation and operation of electric power, electrical engineering, electromechanical complexes and systems.
PRT 26. Understand and explain the importance of traditional and renewable energy for successful economic development of the country.
PRT 31. Combine the methods of empirical and theoretical research to find ways to reduce the loss of electric energy in its production, transportation, distribution and use.

Student workload

The total volume of the course is 120 hours (5 ECTS credits): lectures - 30 hours, workshops - 20 hours, self-study - 70 hours.

Course prerequisites

Physics, Chemistry

Features of the course, teaching and learning methods, and technologies

Lectures employ modern multimedia tools to enhance the learning experience. Workshops are structured around a mix of student preparatory self-study and collaborative team activities. Knowledge and skills cultivated during practical sessions are further reinforced as students tackle individual computational tasks.

Program of the course

Topics of the lectures

Topic 1. Introduction to Bioenergy
Overview of global trends in bioenergy development and a basic understanding of biomass classification.
Topic 2. Biomass Energy & Solid Biofuel
Delve into the significance of energy plants and explore the methodologies behind direct combustion technologies.
Topic 3. Biomass to Fuel Conversion
A detailed look into the conversion processes of biomass, focusing primarily on methanogenic fermentation techniques.
Topic 4. Granulated Biofuel
Understanding the basics of granulated biofuel, its classifications, and the predominant production technologies in use today.
Topic 5. Biogas Production
Unpacking the decomposition methods of organic waste and the essential raw materials used in biogas production, emphasizing methanogenic fermentation.
Topic 6. Biogas Technologies
A comprehensive dive into the infrastructure surrounding biogas production, from methane tanks and gas holders to biogas purification systems.
Topic 7. Biohydrogen
Providing a foundational knowledge of biohydrogen, its production methods, and the intricacies of microbial conversion techniques.
Topic 8. Bioreactors for Hydrogen Production
Explore the diverse world of bioreactors, highlighting photo-bioreactors and the dark fermentation processes.
Topic 9. Biomass Gasification
Uncover the concepts, processes, and classifications that underpin the complex world of biomass gasification.
Topic 10. Biomass Pyrolysis
A holistic examination of pyrolysis, focusing on raw material sourcing and the various classifications of the pyrolysis process.
Topic 11. Biofuels for Internal Combustion Engines (Part 1)
Delving into diesel engines, this lecture sheds light on the characteristics of biodiesel as a prominent biofuel source.
Topic 12. Biofuels for Internal Combustion Engines (Part 2)
A continuation from the previous topic, this lecture covers spark ignition engines and offers an overview of their associated biofuels.
Topic 13. Alcoholic Biofuels
Dive into the world of alcoholic biofuels, covering bioethanol, biomethanol, and biobutanol in depth.
Topic 14. Esters and Advanced Biofuels
A comprehensive understanding of esters, their characteristics, and the modern production techniques employed in the creation of advanced biofuels.
Topic 15. Future Trends and Challenges in Bioenergy
A forward-looking discussion on the evolving trends, opportunities, and challenges in the realm of bioenergy.

Topics of the workshops

Topic 1. Biomass Classification and Analysis

Hands-on experience in classifying different biomass types and understanding their unique properties for energy applications.

Topic 2. Direct Combustion of Solid Biofuels

Practical exercises in calculating and evaluating energy yields from various energy plants through direct combustion.

Topic 3. Methanogenic Fermentation Techniques

Engage in hands-on experiments to understand the fermentation process and derive biofuel from biomass.

Topic 4. Granulated Biofuel Production

Practice creating granulated biofuels, focusing on pellet production from different raw materials, such as freshly cut wood and straw.

Topic 5. Biogas Production from Organic Waste

Workshop dedicated to the decomposition methods of organic waste, understanding the essential raw materials and conditions for optimized biogas production.

Topic 6. Designing Biogas Production Infrastructure

Practical exercises in designing and understanding the integral parts of a biogas plant, including methanogenic tanks and gas purification systems.

Topic 7. Production Techniques for Biohydrogen

Hands-on experiments related to the various methods of biohydrogen production, with a focus on microbial conversion techniques.

Topic 8. Working with Bioreactors

Understanding and setting up bioreactors for optimal hydrogen production, emphasizing on both photo-bioreactors and dark fermentation reactors.

Topic 9. Biomass Gasification Practices

Engaging in hands-on exercises to understand the gasification process, with focus on fluidized and fixed-bed gasification techniques.

Topic 10. Biomass Pyrolysis Techniques

Practical exploration into pyrolysis techniques, equipment setups, and understanding the products derived from the pyrolysis process.

Topics of the laboratory classes

Self-study

This course offers a comprehensive overview of bio-energy principles, applications, and technologies, urging students to bridge theoretical insights with real-world implementations.

Students are encouraged to study a tangible scenario in their native country where bio-energy, particularly biogas or biofuels, played a significant role in energy provision, system enhancement, or problem-solving. Such an endeavor will amplify their appreciation for the pivotal role bio-energy can play in promoting sustainable and eco-friendly energy solutions.

Dedicate time to computational tasks concerning the design, setup, and optimization of a biodigestor. This exercise should take into account different types of feedstock, production capacities, and regional climatic conditions. Tools and templates will be provided to aid these calculations.

Undertake a research project that examines the current status, challenges, and future prospects of bio-energy in your native country. This research should encompass governmental policies, leading bio-energy projects, technological advancements, and potential areas for improvement.

To ensure a rounded understanding, students are advised to delve into supplementary resources. A handpicked list of journals, articles, software tutorials, and recorded webinars is accessible, facilitating a deeper dive into specific areas not exhaustively tackled during the regular course sessions.

Course materials and recommended reading

1. Demirbas, Ayhan. "Biofuels securing the planet's future energy needs." Energy conversion and management 50.9 (2009): 2239-2249.

2. Rutz, Dominik, and Rainer Janssen. "Biofuel technology handbook." WIP Renewable energies 95 (2007).

3. Das, Debabrata, Namita Khanna, and Chitralekha Nag Dasgupta. Biohydrogen production: fundamentals and technology advances. CRC Press, 2014.
4. Fang, Zhen, and Richard L. Smith Jr, eds. Production of biofuels and chemicals from lignin. Springer, 2016.
5. Brown, Robert C., and Tristan R. Brown. Biorenewable resources: engineering new products from agriculture. John Wiley & Sons, 2013.
6. Kole, Chittaranjan, Chandrashekhar P. Joshi, and David R. Shonnard, eds. Handbook of bioenergy crop plants. CRC Press, 2012.
7. Kumar, Sunil, ed. Biogas. BoD–Books on Demand, 2012.

Assessment and grading

Criteria for assessment of student performance, and the final score structure

The final score for this course is calculated based on a combination of evaluations from module tests, practical and laboratory task achievements, and the execution of individual assignments.
1. Module Tests.
Students can earn up to 40 points from the final exam. The exam evaluate the student's comprehension and knowledge retention from the lecture material.
2. Workshop Assignments.
Engaging and participating in workshops, including quizzes and tasks, can earn students up to 30 points.
3. Individual Assignments.
For the completion of individual assignments students can receive up to 30 points.

Grading scale

Total points	National	ECTS
90–100	Excellent	A
82–89	Good	B
75–81	Good	C
64–74	Satisfactory	D
60–63	Satisfactory	E
35–59	Unsatisfactory (requires additional learning)	FX
1–34	Unsatisfactory (requires repetition of the course)	F

Norms of academic integrity and course policy

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to demonstrate discipline, good manners, kindness, honesty, and responsibility. Conflict situations should be openly discussed in academic groups with a lecturer, and if it is impossible to resolve the conflict, they should be brought to the attention of the Institute's management.
Regulatory and legal documents related to the implementation of the principles of academic integrity at NTU "KhPI" are available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Approval

Approved by	Date, signature 2023	Head of the department Serhii MOSTOVYI
	Date, signature 2023	Guarantor of the educational program Halyna OMELIANENKO