Syllabus
Course Program

Power Equipment of Renewable Energy Installations

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
7

Language of instruction
English

Lecturers and course developers

Mykyta Petrenko

mykyta.petrenko@khpi.edu.ua
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 course provides an in-depth study into the phenomena of electrical discharges and overvoltages, crucial concepts for electrical engineering and related fields. Initially, students will delve into the theory and types of electrical discharges, examining Townsend, Streamer, and other discharge mechanisms in various mediums such as gases, vacuums, and solid dielectrics. Breakdown phenomena and their underlying principles, both in gases and solid dielectrics, will be meticulously explored.
Further emphasis is placed on the practical implications of these phenomena in real-world applications. Students will learn about the potential hazards of overvoltages, the intricacies of lightning as a major source of surge overvoltages, and the design of protection systems to combat these challenges. Different types of arresters and their applications will be highlighted, including tube spark gaps, long spark gaps, and non-linear surge limiters. The course also covers comprehensive aspects of high-voltage insulation structures, ranging from air transmission lines to powerful transformers and capacitors.
Practical and laboratory sessions are strategically intertwined with theoretical lectures to offer hands-on experience. These sessions emphasize calculations, modeling, analysis, and experimental studies related to the course's core concepts. By the end of the course, students will possess both theoretical knowledge and practical skills, ensuring a robust understanding of electrical discharges, overvoltages, and associated protection measures.

Course objectives and goals

The primary objective of this course is to impart a deep understanding of electrical discharges, overvoltages, and their implications in electrical networks. Students will be equipped with the knowledge

and skills to design and analyze protection systems against potential electrical hazards. Through a combination of theoretical lectures and hands-on laboratory and practical sessions, the course aims to produce competent individuals capable of addressing challenges in modern electrical engineering scenarios.

Format of classes

Lectures, workshops, laboratory classes, consultations, self-study. Final control in the form of an examination.

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 150 hours (4 ECTS credits): lectures - 32 hours, workshops - 16 hours, laboratory classes - 16, self-study - 86 hours.

Course prerequisites

Physics, Theoretical Foundations of Electrical Engineering p.1, Theoretical Foundations of Electrical Engineering p.2

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

Lectures employ modern multimedia tools to enhance the learning experience. Laboratory classes are structured around a mix of student preparatory self-study and collaborative team activities. Experiential learning is also an integral part of the coursework, allowing students to learn from real-world scenarios.

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 Renewable Energy and Power Equipment Overview
An introductory exploration of the various renewable energy sources and the key equipment involved in harnessing and converting energy.
Topic 2. Solar Energy Equipment Overview
An in-depth look at solar energy systems, focusing on solar panels, their components, and the associated equipment for energy conversion.
Topic 3. Wind Energy Systems and Turbine Technology
A study of wind energy generation, emphasizing the design, operation, and technological aspects of wind turbines.
Topic 4. Hydro Energy Systems and Turbine Dynamics
Analysis of hydro energy systems, delving into the mechanics of hydro turbines and the dynamics of water flow in energy generation.
Topic 5. Fundamentals of Generators for Renewable Energy
Examination of the principles and types of generators used in renewable energy installations, focusing on their roles and operational characteristics.
Topic 6. Battery Technology in Renewable Energy
An exploration of battery technology, covering types, functionalities, and applications in renewable energy storage.
Topic 7. Energy Storage Solutions Beyond Batteries
An overview of alternative energy storage solutions, discussing emerging technologies and their potential roles in renewable energy systems.
Topic 8. Inverter Technology and Applications
Detailed study of inverters, including their function in converting generated electricity for practical use and their integration in renewable energy systems.
Topic 9. Switchgear in Renewable Energy Systems
A look into switchgear technology, focusing on its role in protection and control within renewable energy installations.
Topic 10. Monitoring and Management Devices in Renewable Installations
Examination of the devices and systems used for monitoring and managing renewable energy installations, ensuring efficiency and reliability.
Topic 11. Grid Integration of Renewable Energy Systems
Insights into the challenges and strategies for integrating renewable energy sources into the existing power grid.
Topic 12. Maintenance and Safety of Power Equipment
Discussion of the maintenance protocols and safety measures crucial for the longevity and safe operation of renewable energy equipment.
Topic 13. Efficiency Optimization in Power Equipment
Techniques and methodologies for enhancing the efficiency and performance of power equipment used in renewable energy systems.
Topic 14. Designing and Evaluating Switchgear for Renewable Installations
In-depth analysis of the design considerations and evaluation criteria for switchgear in renewable energy systems.
Topic 15. Solar Energy System Component Integration
Examination of the integration process for various components within a solar energy system, focusing on efficiency and compatibility.
Topic 16. Future Trends and Innovations in Renewable Energy Equipment
Exploration of emerging technologies and trends in renewable energy equipment, forecasting the future direction of the industry.

Topics of the workshops

Topic 1. Assessing Different Renewable Energy Sources and Associated Equipment
Students learn to evaluate the characteristics and equipment of various renewable energy sources, assessing their applicability and efficiency.
Topic 2. Solar Equipment Efficiency and Suitability Assessment
A focused analysis on solar energy components, guiding students through the process of determining efficiency and suitability for different applications.
Topic 3. Design and Analysis of Wind Turbine Systems
Hands-on experience in the design and analytical assessment of wind turbines, exploring aerodynamics, materials, and system integration.
Topic 4. Hydro Turbine Design and Performance Calculations
Detailed calculations and design considerations for hydro turbines, including flow dynamics and energy conversion efficiency.
Topic 5. Comparative Analysis of Generators for Different Energy Sources
Comparative studies of generators used in various renewable energy installations, highlighting the adaptations and performance metrics for each application.
Topic 6. Battery Sizing and Efficiency Calculations
Exercises in determining the optimal size and efficiency of batteries for specific renewable energy systems, considering demand profiles and storage capacity.
Topic 7. Energy Storage System Integration and Assessment
An examination of integrating various energy storage solutions into renewable systems, assessing their compatibility and performance.
Topic 8. Simulating Inverter Operations and Performance
Description: Simulations to analyze inverter performance in renewable energy systems, focusing on efficiency, grid synchronization, and power quality.

Topics of the laboratory classes

Topic 1. Equipment Selection for Diverse Renewable Energy Scenarios
Practical activities in selecting appropriate equipment for different renewable energy scenarios, considering factors like resource availability and system requirements.
Topic 2. Solar Energy System Component Integration and Testing
Hands-on integration and testing of various solar energy system components, ensuring optimal performance and system coherence.
Topic 3. Wind Turbine Power and Load Simulation
Simulations of wind turbine operations under different power and load conditions, analyzing performance and stability.
Topic 4. Hydro Turbine Flow and Efficiency Modelling
Modelling the flow dynamics and efficiency of hydro turbines, using computational tools to predict performance under varying conditions.
Topic 5. Generator Performance Analysis for Renewable Applications
Analytical exercises to evaluate generator performance in renewable energy applications, focusing on output, efficiency, and durability.
Topic 6. Battery Storage Systems and Load Profiles
Practical exercises in designing battery storage systems, considering load profiles and the integration with renewable energy sources.
Topic 7. Advanced Energy Storage Solutions Analysis
Investigation into advanced energy storage solutions, evaluating their potential and performance in renewable energy applications.
Topic 8. Inverter Efficiency and Compatibility Testing
Testing and analysis of inverter efficiency and compatibility with various renewable energy sources, aiming for optimal system integration.

Self-study

The self-study component of the "Power Equipment of Renewable Energy Installations" course is designed to bridge the gap between theoretical knowledge and practical application. Students are

encouraged to analyze a renewable energy installation in their region, focusing on the employed power equipment and its efficacy. This real-world case study approach enhances their understanding of renewable energy's role in sustainable solutions.

In addition to the case study, students engage in computational exercises to design and optimize various renewable energy systems. These exercises are guided by provided materials and focus on the technical considerations essential for efficient system design.
Furthermore, students undertake a research project to investigate the current landscape, challenges, and future prospects of renewable energy in their home country. This exploration covers policy, technological advancements, and development trends, culminating in an essay that encapsulates their findings.
Supplemental resources, such as articles and webinars, are also part of the self-study, offering students the opportunity to delve deeper into specific topics and broaden their understanding. This comprehensive approach to self-study not only enhances theoretical knowledge but also sharpens practical skills, ensuring students are well-prepared for real-world applications in the field of renewable energy.

Course materials and recommended reading

1. Chudnovsky, Bella H. Transmission, distribution, and renewable energy generation power equipment: Aging and life extension techniques. CRC Press, 2017.
2. Twidell, John. Renewable energy resources. Routledge, 2021.
3. Infield, David, and Leon Freris. Renewable energy in power systems. John Wiley & Sons, 2020.
4. Maegaard, Preben, Anna Krenz, and Wolfgang Palz, eds. Wind power for the world: international reviews and developments. Vol. 3. CRC Press, 2013.

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 exam, workshop and laboratory class achievements, and the execution of individual assignments.
1. Final Examination.
Students can earn up to 40 points from the final module tests. The tests evaluate the student's comprehension and knowledge retention from the lecture material.
2. Workshop and Laboratory 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