Syllabus
Course Program

Application of Solar Energy

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
5

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 "Application of Solar Energy" course is a thorough journey into the realm of solar energy. Students start with the basics, learning what the sun is, the nature of solar energy, where it comes from, and the spectrum of solar radiation. The course highlights the importance of renewable energy and the drawbacks of conventional energy sources.
Students then explore ways to capture and utilize solar energy, beginning with simple methods like using black paint for heat absorption and progressing to complex technologies such as solar thermal collectors and photovoltaic panels. The course dives into the physics behind photovoltaic panels, particularly the pn-junction.
Different types of photovoltaic panels are examined, including monocrystalline, polycrystalline, and thin-film, along with their strengths and weaknesses. While the course briefly touches upon other solar station equipment, its focus remains on solar technology itself. An in-depth look at solar thermal collectors is also included, covering all related equipment and details. The course concludes by considering the future potential and developments in solar energy.

Course objectives and goals

The "Application of Solar Energy" course aims to provide students with a solid understanding of solar energy and its applications. Students will begin by learning the fundamental concepts of solar energy, its environmental significance, and the risks associated with traditional energy sources. The course gradually moves from basic techniques for harnessing solar energy to more complex systems like photovoltaic panels and solar thermal collectors.

A significant focus is placed on the physics of photovoltaic panels, especially the pn-junction, and the types of panels available in the market. While the course includes a brief overview of additional solar installation equipment, it primarily concentrates on solar energy technologies. Finally, students will explore the potential future advancements in solar energy. The aim is to prepare individuals who are well-versed in solar energy technology and its applications in the modern world.

Format of classes

Lectures, workshops, 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 (5 ECTS credits): lectures - 32 hours, workshops - 32 hours, 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. Workshops classes 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 Solar Energy: Understanding the Sun and Solar Radiation
A foundational overview exploring the nature of the sun, solar energy, its origin, and the spectrum of solar radiation.
Topic 2. Basic Methods for Harnessing Solar Energy
Exploration of simple solar energy capture methods, including basic heating techniques and their applications.
Topic 3. Introduction to Photovoltaic Energy: The Science of Converting Light to Electricity
An introductory look at the principles of photovoltaic energy and the basic technology that enables the conversion of light into electrical energy.
Topic 4. Exploring the pn-Junction: The Core of Photovoltaic Technology
Delving into the physics behind photovoltaic cells, focusing on the role and functioning of the pn-junction.
Topic 5. Types of Photovoltaic Panels: Monocrystalline, Polycrystalline, and Thin-Film
A comparative study of the main types of photovoltaic panels, discussing their respective advantages and limitations.
Topic 6. Advantages and Disadvantages of Different Photovoltaic Technologies
An evaluative session examining the various photovoltaic technologies and their suitability for different applications.
Topic 7. Basics of Solar Energy Capture: From Panels to Systems
An overview of how solar energy is captured and transformed, from individual panels to complete solar systems.
Topic 8. Overview of Solar Station Equipment: Beyond Panels
A brief exploration of additional solar station equipment, laying the groundwork for more detailed study in concurrent courses.
Topic 9. Solar tracking
Understanding the fundamentals of solar tracking.
Topic 10. In-depth Study of Solar Thermal Collectors
A comprehensive study of solar thermal collectors, their components, and their role in solar energy systems.
Topic 11. Principles and Applications of Solar Thermal Energy
Understanding the fundamentals of solar thermal energy and its various applications in heating and power generation.
Topic 12. The Components and Functioning of Solar Thermal Systems
A detailed examination of the various components within solar thermal systems and how they work together to harness and utilize solar thermal energy.
Topic 13. Integrating Solar Energy into the Grid: Challenges and Solutions
Discussion of the practical and technical challenges involved in integrating solar energy into the existing power grid, and potential solutions.
Topic 14. Maintenance and Efficiency Optimization of Solar Installations
An exploration of the maintenance requirements for solar installations and strategies for optimizing their efficiency over time.
Topic 15. Innovations and Emerging Trends in Solar Technology
Investigation of the latest innovations in solar technology and emerging trends that could shape the future of solar energy.
Topic 16. The Future of Solar Energy: Prospects and Potentials
A forward-looking session examining the potential developments in solar energy and its role in the global energy landscape.

Topics of the workshops

Topic 1. Measuring Solar Radiation and Understanding Its Patterns

Participants will learn to measure and analyze solar radiation patterns using various instruments and data sources.

Topic 2. Simulating Solar Energy Capture: Practical Approaches

A hands-on session where students simulate basic methods of solar energy capture, enhancing understanding of theoretical concepts.

Topic 3. Designing Simple Photovoltaic Cells: From Theory to Practice

Participants will engage in the practical design of simple photovoltaic cells, applying their understanding of the photovoltaic effect.

Topic 4. Assessing Photovoltaic Panel Efficiency: Monocrystalline vs. Polycrystalline

A comparative workshop focusing on assessing the efficiency of different types of photovoltaic panels under varying conditions.

Topic 5. Constructing a Basic Solar Thermal System: A Practical Exercise

Students will collaboratively construct a basic solar thermal system, applying theoretical knowledge to practical implementation.

Topic 6. Solar Energy System Design: Incorporating Panels and Beyond

An exercise in designing a comprehensive solar energy system, incorporating panels and other necessary components.

Topic 7. Troubleshooting and Optimizing Solar Installations: A Practical Approach

Participants will engage in troubleshooting common issues in solar installations and explore strategies to optimize performance.

Topic 8. Emerging Solar Technologies: Hands-On Exploration

A workshop dedicated to exploring and experimenting with emerging solar technologies, fostering innovation and forward thinking.

Topics of the laboratory classes

Self-study

This course invites students to link solar energy theory with practical application by analyzing a real-world case study from their region. This deepens understanding of solar energy's impact on sustainable solutions.

Students will engage in computational exercises to design and optimize solar energy systems, considering various technical factors. Materials will be provided to guide these tasks.

Additionally, a research project will explore solar energy's current landscape, challenges, and future in the students' home country, covering policy, technology, and development areas.

Supplemental resources, including articles and webinars, will support a deeper dive into specific topics, rounding out the learning experience. This self-study approach not only broadens knowledge but also sharpens practical skills in solar energy.

Course materials and recommended reading

1. Markvart, Tom, ed. Practical handbook of photovoltaics: fundamentals and applications. Elsevier, 2003.
2. Quaschning, Volker. Understanding renewable energy systems. Routledge, 2014.
3. Peake, Stephen. Renewable energy-power for a sustainable future. No. Ed. 4. OXFORD university press, 2018.
4. Wengenmayr, Roland, and Thomas Bührke, eds. Renewable energy: sustainable energy concepts for the future. John Wiley & Sons, 2008.
5. Kalogirou, Soteris A. Solar energy engineering: processes and systems. Academic press, 2013.
6.Duffie, John A., and William A. Beckman. Solar engineering of thermal processes. John Wiley & Sons, 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, practical 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 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	Head of the department Serhii MOSTOVYI
	Date, signature	Guarantor of the educational program Halyna OMELIANENKO