Ministry of Education and Science of Ukraine
National Aerospace University
Kharkiv Aviation Institute

Department of Space Technology and Non-Traditional Energy Sources (No. 402)

"APPROVED"

Guarantor of the educational program
_____ Andriy POGUDIN
August 29, 2025

SYLLABUS OF THE MANDATORY EDUCATIONAL DISCIPLINE

"Power Plants, Grids, and Systems"

Field of knowledge: 14 "Electrical Engineering"

Specialty: 141 "Electric Power Engineering, Electrical Engineering, and Electromechanics"

Educational programs: "Non-traditional and Renewable Energy Sources"

Level of higher education: first (bachelor's)

Syllabus effective from 01.09.2025

Kharkiv – 2025

Developer: Shepetov Yu.O., Assoc. Prof. k.402, Ph.D., Associate Professor _____

The syllabus for the academic discipline was reviewed at a meeting of the Department of Space Technology and Non-Traditional Energy Sources

Minutes No. __1__ dated August 28, 2025

Acting Head of the Department, Ph.D., Associate Professor _____ Yuriy SHEPETOV

Approved by the representative of the students:

Olexandr LISIN

_____ _____ _____

(signature) (first and last name)

1. General information about the teacher

Full name: Yurii Shepetov
Position: Associate Professor
Academic degree: Candidate of Technical Sciences
Academic title: Associate Professor
List of disciplines taught: "Power Plants, Grids, and Systems," "Fundamentals of the Theory and Functioning of Power Plants," "Regulatory and Legal Framework in Energy," "Issues of Intellectual Property and Scientific and Engineering Developments."
Areas of scientific research: space energy, ground-based solar energy.
Contact information: +38066-485-7614 i.shepetov@khai.edu

2. Description of the academic discipline

Form of education	Full-time
Semester	6
Language of instruction	Ukrainian
Type of discipline	Compulsory
Scope of the discipline: ECTS credits/number of hours	Full-time: 6.5 ECTS credits / 195 hours (80 classroom hours, of which: lectures – 48, practical classes – 32; independent study – 115)
Types of educational activities	Lectures, practical (seminar) classes, independent work
Types of assessment	Continuous assessment, modular assessment, semester assessment – exam
Prerequisites	Physics, Electrical Engineering, Industrial Electronics Devices for Non-Traditional Installations
Co-requisites	"Electrical Equipment of Power Plants"
Post-requisites	"Design of solar and thermal power plants," "Design of renewable energy sources"

3. Purpose and objectives of the academic discipline, lists of competencies and expected learning outcomes

Objective: to develop a system of professional knowledge on the principles of construction and operation of electrical networks, the main technical and operational characteristics of electrical power system equipment .

Objective:

Objectives: to acquire theoretical knowledge of the principles of construction and operation of electrical networks; practical skills in performing engineering calculations for the selection of electrical network equipment.

Competencies acquired:

Integral competence: The ability to solve specialized tasks and practical problems during professional activities in the field of electric power engineering, electrical engineering, and electromechanics, or in the learning process, which involves the application of theories and methods of physics and engineering sciences and is characterized by complexity and uncertainty of conditions.

General competencies (GC)

Upon completion of this program, the student will be able to:

- *learn and master modern knowledge.*
- *apply knowledge in practical situations.*
- *make decisions and act in accordance with the principle of zero tolerance for corruption and any other manifestations of dishonesty.*

Special competencies:

Upon completion of this program, students will be able to:

- solve complex specialized tasks and practical problems related to the operation of electrical systems and networks, the electrical part of non-traditional and renewable energy facilities.

- solve complex specialized tasks and practical problems related to metrology, electrical measurements, the operation of automatic control devices, relay protection, and automation at non-traditional and renewable energy facilities.

- solve complex specialized tasks and practical problems related to the production, transmission, and distribution of electrical energy at non-traditional and renewable energy facilities.

- understand the need to improve the efficiency of electrical, electrotechnical, and electromechanical equipment at non-traditional and renewable energy facilities.

- take effective measures in emergency situations at non-traditional and renewable energy facilities.

Program learning outcomes:

- Know and understand the principles of operation of electrical systems and networks, power equipment of power plants and substations, protective grounding and lightning protection devices, and be able to use them to solve practical problems in professional activities.

- Know and understand the theoretical foundations of metrology and electrical measurements, the principles of operation of automatic control devices, relay protection, and automation, and have the skills to perform the appropriate measurements and use these devices to solve professional tasks.

- Select and apply suitable methods for the analysis and synthesis of electromechanical and electrical power systems in renewable energy.

- Understand the importance of traditional and renewable energy for the successful economic development of the country.

- Apply appropriate empirical and theoretical methods to reduce electrical energy losses during its production, transmission, distribution, and use.

4. Course content

Content module No. 1

TOPIC 1. Structure and composition of the energy sector in Ukraine.

Structure and composition of Ukraine's energy sector. Functions and tasks of the state-owned enterprise "Energorynok." Economic and operational subordination of energy production facilities. Structure of operational management of energy production. Functions and tasks of the Central Dispatch Service (CDS) of Ukraine. Functions and tasks of the Central Dispatch Administration (CDA) of the Unified Energy System of Ukraine (UESU). Functions and tasks of the regional dispatch administration (DA). Functions and tasks of the dispatch service (DS) of the regional power distribution companies. Functions and tasks of the DS of the district electrical networks (DEN). Main types of power plants used in Ukraine, their characteristics. Share participation of different types of power plants in the typical load schedule of the energy system of Ukraine.

Lectures: "*Structure and composition of the energy sector in Ukraine*."

Practical classes: *none.*

Independent work of the student: *studying the lecture material, completing a test on the theoretical material.*

TOPIC 2. Main components of energy systems.

Types of electrical diagrams for electrical systems and networks. Basic symbols. Types of power systems. System components. Purpose of components. Main networks. Distribution networks. Network equipment. Power lines. Transforming substations. Connection between systems. Power system operating modes – normal, emergency, post-emergency. Purpose of relay protection. Types of neutrals – solidly grounded, isolated, compensated. Grounding – working and protective. Principles of operation of RCDs, RCDs. Phase symmetry in networks. Phase asymmetry. Consequences of a broken neutral wire in a network with a solidly grounded neutral. Measures to protect single-phase receivers from phase voltage deviations.

Lectures: "*Basic components of power systems, part 1*," "*Basic components of power systems, part 2*."

Practical classes: *"Determination of zero, forward, and reverse sequence currents in a network with a solidly grounded neutral in the event of a zero wire break*."

Independent work of the student: *studying the lecture material, completing an individual practical assignment and preparing for its defense, completing a test on the theoretical material*.

TOPIC 3. Loading of power systems.

Types of loads and their characteristics – industrial, municipal and domestic, agricultural. Typical daily and seasonal load schedules. Repair pit. Load forecasting – long-term, medium-term, operational. Load management – administrative and economic. Typical load characteristics in Ukraine. Load schedule coefficients. Calculation of industrial loads. Calculation of municipal and domestic loads. Load center. Electrical energy losses.

Lectures: "*Loads of electric power systems,* part 1," "*Loads* of *electric power systems,* part 2," "*Loads* of *electric power systems, part* 3," "*Loads* of *electric power systems, part 4*."

Practical classes: *"Calculation of loads of an industrial enterprise," "Calculation of loads in a 0.4 kV network*."

Independent work of the student: *studying lecture material, completing individual practical assignments and preparing for their defense, completing a test on theoretical material*.

TOPIC 4. Power transmission lines.

Cable and overhead power lines (PLC). History. Voltage ratings. Main design characteristics of overhead PLCs and cable PLCs. Direct current PLCs. Basic principles for selecting PLC cross-sections – ensuring emergency mode current, economic current density, and permissible voltage losses. Maintenance of main power lines. Types of power line calculations – by permissible heating current, by permissible voltage losses, by reliability of protection operation, by economic current density. Annual electricity losses in power lines. Induced electricity consumption.

Lectures: "*Power transmission lines,* part 1," "*Power transmission lines,* part 2," "*Power transmission lines, part 3*."

Practical classes: *"Calculation of a 0.4 kV network," "Economic current density*."

Independent work of the student: *studying lecture material, completing individual practical assignments and preparing for their defense, completing a test on theoretical material*.

TOPIC 5. Operation of distribution networks.

Topology of distribution networks. Categories of consumers with requirements for ensuring the reliability of electricity supply. The main types of distribution network schemes, their advantages and disadvantages, recommended cases of application - radial, loop, double-arm unilateral, double-arm bilateral schemes. Short circuit. Calculation of networks for short-circuit resistance. Calculation of a network with two- sided power supply. Internal networks of buildings.

Lectures: "*Distribution* network *topology*," "Consumer *categories*," "*Short* circuit*," "Internal building networks, part 1," "Internal building networks, part 2."*

Practical classes: *"Calculation of a network with two-way power supply," "Calculation of loads and selection of cross-sections of power lines in a 10 kV network*."

Independent work of the student: *studying lecture material, completing individual practical tasks and preparing for their defense, preparing for a modular test, completing a test on theoretical material*.

Content module No. 2

TOPIC 6. Transformers.

Types of electrical transformers used in electrical systems, their purpose and application. Designation of transformers. Temperature conditions for transformer operation. Factors determining the service life of transformers. Relative service life. Calculation of permissible systematic loads. Calculation of permissible emergency

overloads. Permissible overexcitation of transformers. Winding connection groups. Current transformers. Voltage transformers.

Lectures: "*Types of electrical* transformers," "*Issues of electrical transformer operation*."

Practical classes: *"Calculation of the normally permissible load of a transformer*."

Independent work of the student: *studying lecture material, completing an individual practical assignment and preparing for its defense, completing a test on theoretical material*.

TOPIC 7. Switching devices.

Types of electrical switching devices used in electrical systems, their purpose and application. Oil, low-oil, air, electromagnetic, gas-insulated, and vacuum circuit breakers – design and areas of application. Disconnectors – design and areas of application. Selection of switching devices – by rated voltage, by permissible current, by short-circuit current resistance.

Lectures: *"Switching devices*.

Practical classes: *"Selection of switching devices*."

Independent work of the student: *studying the lecture material, completing an individual practical assignment and preparing for its defense, completing a test on the theoretical material*.

TOPIC 8. Electrical substations.

Main diagrams of distribution devices and their areas of application. Design principles for the layout of electrical substations. Selection of the operating diagram for a substation.

Lectures: "*Main diagrams of distribution* devices," "*Design principles of electrical substations*."

Practical classes: *"Design principles of electrical substations*."

Independent work of the student: *studying the lecture material, completing a test on the theoretical material*.

TOPIC 9. Compensation of reactive currents in networks.

The need for reactive current compensation. Ways to increase the power factor – organizational and technical. Means of reactive current compensation. Calculation of the necessary compensation means.

Lectures: "*Compensation of reactive currents in networks*."

Practical classes: *"Calculation of the required compensation power*."

Independent work of the student: *studying the lecture material, completing a test on the theoretical material*.

TOPIC 10. Reliability of electrical networks. Organization and procedure for switching in electrical installations of 0.4 - 10 kV distribution networks.

Operational status of equipment. – operation, repair, reserve. Criteria for the current operational status for different types of equipment. Change in the operational status of equipment. Operational control and operational management. Switching orders. Switching forms – purpose, composition, order of compilation. Procedure for

personnel during switching. Operational discipline. Operational actions. Performing switching in 0.4-10 kV electrical installations. Sequence of basic operations with switching devices and verification actions when connecting and disconnecting electrical circuits. Example of a training operational diagram of a distribution network, development of a switching procedure and a switching form for the training diagram. Telemechanics and communication in distribution networks. Types of possible system failures in electrical networks. The role of the human factor in the operation of energy production facilities. Automation and relay protection.

Lectures: "*Organization and procedure for switching in electrical installations*."

Practical classes: *"Compiling operational diagrams of the 0.4 kV network," "Compiling the order of switching in the network.*"

Independent work of the student: *studying the lecture material, completing an individual practical assignment and preparing for its defense, completing a test on the theoretical material*.

TOPIC 11. Quality of electrical energy.

Electricity quality indicators. Normal and maximum permissible indicators. Frequency deviations – causes and consequences. Voltage deviations – causes and consequences. The effect of voltage deviations on the operation of electrical appliances – incandescent lamps, fluorescent lamps, asynchronous motors, electric furnaces. Voltage control. Distortion of voltage and current waveforms.

Lectures: "*Electricity quality*."

Practical classes: *"Determining the quality indicators of electrical energy*."

Independent work by students: *studying lecture material, completing a test on theoretical material*.

TOPIC 12. PUE.

Rules for the installation of electrical installations - PUE. Purpose of PUE, current version of PUE, composition of PUE.

Lectures: "PUE is the main regulatory document for the operation of electrical networks and electrical equipment."

Practical classes: *"Familiarization with the composition of the current edition of the PUE*."

Independent work of the student: *studying the lecture material, preparing for the module test, completing a test on the theoretical material*.

5. Individual assignments

Different options for initial data when performing practical tasks.

6. Teaching methods

Classroom lectures, laboratory work, individual consultations (if necessary), independent work by students using materials published by the department (methodological guides).

7. Assessment

Checking and defending practical tasks, RR, exam.

8. Assessment criteria and distribution of points received by students

Table 8.1 – Distribution of points awarded to students

Components of academic work	Points per class (assignment)	Number of classes (assignments)	Total number of points
Content module 1			
Completion and defense of practical work	3	7	21
Modular control	15	1	15
Content module 2			
Completion and defense of laboratory (practical) work	3	3	9
Modular control	15	1	15
Total for the semester			**60**

Semester control (exam) is conducted in case of refusal of the student to receive final control points and if the student is admitted to the exam. During the semester exam/test, the student has the opportunity to receive a maximum of 100 points.

The exam ticket consists of two theoretical questions and a practical task. The maximum number of points for answering each theoretical question is 30 points, and for completing the practical task is 40 points.

Criteria for evaluating the student's work during the semester

Required knowledge to receive a positive grade:

Structure and composition of Ukraine's energy sector. Functions and tasks of the state-owned enterprise Energorinok. Main types of power plants used in Ukraine and their characteristics. Share of different types of power plants in the typical load schedule of Ukraine's power system. Types of electrical diagrams for electrical systems and networks and main symbols. They include the composition of electrical systems. Types of neutrals – solidly grounded, isolated, compensated. Principles of operation of RCDs, DGRs. Phase symmetry in networks. Types of loads and their characteristics – industrial, municipal and domestic, agricultural. Load schedule coefficients. Calculation of industrial loads. Calculation of municipal and domestic loads. Load center. Electrical energy losses. Basic design characteristics of overhead power lines and cable power lines. Basic principles for selecting the cross-section of power lines – ensuring emergency mode current, economic current density, and permissible voltage losses. Types of power line calculations – by permissible heating current, by permissible voltage losses, by protection reliability, by economic current density. Annual power losses in power lines. Induced power consumption. Distribution network topology. Categories of consumers with requirements for ensuring the reliability of electricity supply. The main types of distribution network schemes, their advantages and disadvantages, recommended applications - radial, loop, double-arm unilateral, double- arm bilateral schemes. Short circuit. Calculation of networks for short-circuit resistance.

Calculation of a network with two-way power supply. Types of electrical transformers used in electrical systems, their purpose and application. Designation of transformers. Temperature conditions for transformer operation. Factors determining the service life of transformers. Relative service life. Calculation of permissible systematic loads. Calculation of permissible emergency overloads. Winding connection groups. Current transformers. Voltage transformers. Types of electrical switching devices used in electrical systems, their purpose and application. Oil, low-oil, air, electromagnetic, gas-insulated, and vacuum circuit breakers – design and areas of application. Disconnectors – design and areas of application. Selection of switching devices – by rated voltage, by permissible current, by resistance to short-circuit currents. Main diagrams of distribution devices and their areas of application. Design principles for the layout of electrical substations. Selection of the operating diagram for a substation. The need for reactive current compensation. Ways to increase the power factor – organizational and technical. Means of reactive current compensation. Calculation of the necessary compensation means. Reliability of electrical networks. Organization and procedure for switching in electrical installations of 0.4 - 10 kV distribution networks. Operational status of equipment – operation, repair, reserve. Criteria for the current operational status for different types of equipment. Change in the operational status of equipment. Procedure for personnel during switching. Operational discipline. Operational actions. Performing switching in 0.4-10 kV electrical installations. Sequence of basic operations with switching devices and verification actions when connecting and disconnecting electrical circuits. Telemechanics and communications in distribution networks. Types of possible system failures in electrical networks. The role of the human factor in the operation of energy production facilities. Automation and relay protection. Electricity quality indicators. Normal and maximum permissible indicators. Frequency deviations – causes and consequences. Voltage deviations – causes and consequences. The effect of voltage deviations on the operation of electrical receivers – incandescent lamps, fluorescent lamps, asynchronous motors, electric furnaces. Voltage control. Distortion of voltage and current waveforms.

Required skills for a positive assessment:

Determination of zero, forward, and reverse sequence currents in a network with a solidly grounded neutral in the event of a zero wire break. Calculation of loads for an industrial enterprise. Calculation of loads in a 0.4 kV network. Calculation of a 0.4 kV network. Calculation of power line cross-sections based on the criterion of economic current density. Calculation of a network with two-way power supply. Calculation of a 10 kV network. Calculation of the normally permissible transformer load. Compilation of operational diagrams of a 0.4 kV network. Compilation of the switching order in the network.

Satisfactory (60-74). Have a minimum of knowledge and skills. Complete and defend all practical work. Demonstrate understanding of the basic provisions of the calculation methodology.

Good (75-89). Acquire a minimum of knowledge and skills, complete all tasks, defend all practical work and RR within the time frame specified by the instructor, justifying the decisions made. Demonstrate understanding of most of the provisions of the calculation methodology.

Excellent (90-100). Know the basic and additional material thoroughly. Know all topics. Be familiar with textbooks and manuals. Complete all assignments, defend all

practical work within the time frame specified by the instructor, justifying the decisions made. Demonstrate a thorough understanding of all provisions of the calculation methodology.

Grading scale: point-based and traditional

Total points	Traditional scale	
	Exam, differentiated credit	Credit
90	Excellent	Pass
75	Good	
60	Satisfactory	
0	Unsatisfactory	Not counted

9. Course policy

Class attendance. Absence policy. The interactive nature of the course requires mandatory attendance at practical classes. Students who, under certain circumstances, are unable to attend practical classes regularly must agree with the instructor on a schedule for making up missed classes within a week. Individual missed classes must be made up at the next consultation within a week after they were missed. Classes are made up orally in the form of an interview on questions specified in the class plan. In some cases, it is permissible to make up missed classes in writing by completing an individual written assignment.

Compliance with the requirements of academic integrity by students while studying the academic discipline. When studying an academic discipline, students must adhere to generally accepted moral and ethical norms and rules of conduct, as well as the requirements of academic integrity provided for in the Regulations on Academic Integrity of the National Aerospace University "Kharkiv Aviation Institute" (https://khai.edu/assets/files/polozhennya/polozhennya-pro-akademichnu-dobrochesnist.pdf). It is expected that the work of students will be their original research or reflections. The absence of references to sources used, fabrication of sources, plagiarism, and interference in the work of other students are examples of possible academic misconduct, but are not limited to these. The detection of signs of academic misconduct in a student's written work is grounds for its rejection by the teacher, regardless of the extent of plagiarism or deception.

Conflict resolution. The order and procedures for resolving conflicts related to corrupt practices, conflicts of interest, various forms of discrimination, sexual harassment, interpersonal relationships, and other situations that may arise during training, as well as rules of ethical conduct are regulated by the Code of Ethical Conduct at the National Aerospace University "Kharkiv Aviation Institute" (https://khai.edu/ua/university/normativna-baza/ustanovchi-dokumenti/kodeks-etichnoi-povedinki/).

10. Methodological support

1. Perpechen V.O. Methodological recommendations for performing laboratory work in the academic discipline "Electrical Systems and Networks (for full-time

and part-time students and students of second higher education in specialty 141 "Electric Power Engineering, Electrical Engineering and Electromechanics"/ - Kharkiv: O.M. Beketov National University of Civil Engineering and Architecture, 2018. – 39 p.
2. Electrical Systems and Networks: Laboratory Practicum: Textbook for students majoring in 141 "Electric Power Engineering, Electrical Engineering, and Electromechanics" / Igor Sikorsky KPI; comp.: V.V. Kyryk, S.V. Kazansky, T.L. Katsadze, O.B. Besarab.
3. Power cables. Collection of regulatory documents and methodological guidelines for their use in independent study of the course "Cable and overhead power lines" (for 4th-year full-time and 5th-year part-time students majoring in 6.050701 "Electrical Engineering and Electrical Technologies" (0906 "Electrical Engineering") in the specialty "Electrical Power Consumption Systems") / Kharkiv National Academy of Municipal Economy; compiled by: E.D. Dyakov. – Kharkiv: KNAME, 2011. – 55 p.
4. https://mentor.khai.edu/course/view.php?id=4839

11. Recommended reading

Basic

1. Segeda M.S. Electrical Networks and Systems: Textbook. – 2nd ed. – Lviv: Publishing House of Lviv Polytechnic National University, 2009. – 488 p.
2. Konyukhova E.A. Power supply of facilities: Tutorial. – Kyiv: Mastery Publishing House, 2002. – 320 p.: ill.

Supplementary

1. Kyryk, V. V. Electrical Networks. Textbook [Electronic resource]: textbook for bachelor's degree students majoring in 141 "Electrical Power Engineering, Electrical Engineering, and Electromechanics" / V. V. Kyryk; Igor Sikorsky Kyiv Polytechnic Institute. - Electronic text data (1 file: 5.84 MB). - Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2021. - 281 p.

12. Information resources

1. State Enterprise "Energorynok" [Electronic resource] – Access modehttp://www.er.energy.gov.ua
2. National Energy Company Ukrenergo [Electronic resource] – Access mode https://ua.energy
3. National Energy Regulatory Commission [Electronic resource] – Access mode http://www.nerc.gov.ua
4. Electric Networks website [Electronic resource] – Access mode http://leg.co.ua/