National Technical University of Ukraine
Igor Sikorsky Kyiv Polytechnic Institute "

Department of Renewable Energy Sources

ELECTRICAL EQUIPMENT OF ELECTRIC POWER PLANTS AND SUBSTATIONS

Working program of the academic discipline (Syllabus)

Details of the academic discipline

Level of higher education	***First (undergraduate)***
Discipline	*14 "Electrical engineering"*
Specialty	*141 « Electric power, electrical engineering and electromechanics"*
Educational program	*ELECTROMECHANICAL AUTOMATION SYSTEMS, ELECTRIC DRIVE AND ELECTRIC MOBILITY, ELECTRIC MACHINES AND APPARATUS*
Discipline status	*Normative*
Form of education	*Full-time/remote*
Year of training, semester	*III year, autumn semester*
Scope of the discipline	*4 credits/ECTS 120 hours (lectures – 36, laboratory sessions – 18, independent work – 66)*
Semester control/ control measures	*Examination/MKR/testing with L.R.*
Class schedule	*Lecture classes - 1 time per week; laboratory classes - once every two weeks*
Language of teaching	*Ukrainian*
Information about the head of the course / teachers	Lecturer: *Doctor of Technical Sciences, Associate Professor Oleksandr Volodymyrovych Ostapchuk , O. Ostapchuk @ kpi . u.a* Laboratory: *Oleksandr Leonidovych Bondarenko*
Placement of the course	https://do.ipo.kpi.ua/course/view.php?id=6977

Program of study discipline

1. Description of the educational discipline, its purpose, subject of study and learning outcomes

The program of the study discipline "Electrical part of stations and substations" is compiled in accordance with the educational and professional training program of bachelors " Electromechanical systems of automation, electric drive and electric mobility ", "Electric machines and devices", fields of knowledge 14 "Electrical engineering" with specialty 141 " Electric power engineering, electrical engineering and electromechanics ".

***The purpose of the educational discipline** is to form students of the following competencies :*

ZK07. Ability to work in a team.

FK02. The ability to solve practical problems involving the methods of mathematics, physics and electrical engineering.

FK03. The ability to solve complex specialized tasks and practical problems related to the operation of electrical systems and networks, the electrical part of stations and substations, and high- voltage equipment .

FK06. The ability to solve complex specialized tasks and practical problems related to the problems of production, transmission and distribution of electric energy.

FK09. Awareness of the need to increase the efficiency of electric power, electrotechnical and electromechanical equipment.

F K10. Awareness of the need to constantly expand one's own knowledge of new technologies in electric power, electrical engineering and electromechanics.

FC11. The ability to quickly take effective measures in emergency (emergency) situations in electric power and electromechanical systems.

Program learning outcomes:

PRN01. Know and understand the principles of operation of electrical systems and networks, power equipment of electrical stations and substations, protective grounding and lightning protection devices and be able to use them to solve practical problems in professional activities.

PRN04. Know the principles of operation of bioenergy, wind energy, hydropower and solar energy installations.

PRN07. To carry out the analysis of processes in electric power, electrotechnical and electromechanical equipment, relevant complexes and systems.

PRN13. To understand the importance of traditional and renewable energy for the successful economic development of the country.

PRN17. Solve complex specialized problems in the design and maintenance of electromechanical systems, electrical equipment of power stations, substations, systems and networks.

2. Pre-requisites and post-requisites of the discipline (place in the structural and logical scheme of training according to the relevant educational program)

To successfully master the discipline, the student must possess knowledge based on the material of previous disciplines, namely: Basics of metrology and electrical measurements., Electric machines. The knowledge gained during the study of this discipline is the basis for the study of the discipline "Electrical networks and systems" in the future.

3. Content of the academic discipline

*The discipline is structurally divided into **4 sections** , namely:*

1. ***Introduction. Basic information about electrical installations** , which includes general information about the stages of development of the electric power industry of Ukraine and the structure of the electric power system (EES), the main definitions of the discipline. Production of electrical energy by types of electrical plants (bio- , wind- , hydro-, and solar). Prospects for the development of renewable energy. Definition of concepts of loss of power and electricity, ways to reduce them, advantages of distributed generation systems. Ways of ensuring power balance in the UES by type of power plants. The electrical part of power plants (requirements for it and its components), conventional designations of elements.*

2. ***The main and auxiliary electrical equipment of power plants** , which included questions about the types, parameters, characteristics and design features of synchronous generators (SG), their cooling and excitation systems. Design features of power transformers and autotransformers, their types, main parameters, schemes and groups of winding connections, performance of cooling systems. Load capacity of power transformers. Main characteristics of auxiliary equipment of electrical stations and substations.*

3. ***Short-circuit currents and the choice of electrical devices** , which included the issue of determining the transient process in the event of a three-phase short-circuit in a circuit with a source of unlimited and limited power. Practical methods and algorithm for calculating the three-phase short-circuit current. Determination of the periodic component of the short-circuit current at a given time. Electrodynamic and thermal effect of short-circuit current. Determination of electrodynamic and thermal stability of electrical appliances. Methods and means of limiting short-circuit currents. Peculiarities of the choice and construction of electrical devices with a voltage of up to and above 1 kV.*

***Primary and secondary circuits at power plants** , which included the issue of determining the requirements for electrical connection schemes of power plants. Diagrams of switchgears (RU), their scope of application and comparison on different types of ECs. Peculiarities of choosing communication transformers at one- and two-transformer substations. Schemes of substations on the example of wind and solar power stations. Schemes of electrical connections of own needs (VP), features of their arrangement at different*

types of electrical stations. Characteristics and modes of operation of electrical energy storage systems. Organization of the control system, signaling, automation and electricity accounting.

4. Educational materials and resources

Main information resources:

1. The electrical part of stations and substations: a course of lectures [Electronic resource]: study guide for students . specialty 141 "Electroenergetics, electrical engineering and electromechanics"/compiler: O.V. Ostapchuk, P.L. Denisyuk, Yu.P. Mateyenko - KPI named after Igor Sikorsky, - Electronic text data (1 file: 4.62 MB). - Kyiv: KPI named after Igor Sikorskyi, 2022. - 183 p. Access mode: https://ela.kpi.ua/handle/123456789/48629

2. Bardyk , E.I. Electrical part of stations and substations. Main electrical equipment/ E.I. Bardyk , M.P. Lukash /K.: "Polytechnic" NTUU "KPI" 2012. 250 p.

3. Kostyshyn , V.S. Electrical part of stations and substations: training . help /V.S. Kostyshyn , M.Y. Fedoriv, Y.V. Batsala - Ivano-Frankivsk: IFNTUNG, 2017. - 243 p.

4. V.M. Garyazh Synopsis of lectures on the course "Electrical part of stations and substations" (part 1) / V.M. Haryazha , A.O. Kariuk; Kharkiv. national city university Mrs. O. M. Beketova. – Kharkiv: XNUMX named after O. M. Beketova, 2018. – 149 p

5. Kozlov V.D. Electrical part of stations and substations of airports: textbook /V.D. Kozlov, V.P. Zakharchenko, O. M. Tachynina ; in general ed. V. D. Kozlova. – K.: NAU, 2018. – 312 p

6. Distance course " Electrical part of stations and substations " https://do.ipo.kpi.ua/course/view.php?id=580

Additional:

1. Electrical part of stations and substations: laboratory workshop [Electronic resource]: training . help for studies specialty 141 "Electroenergetics, electrical engineering and electromechanics" / compiled by Yu.P. Mateyenko , P.L. Denisyuk, H.M. Gaevska, R.V. Vozhakov - KPI named after Igor Sikorskyi; Electronic text data (1 file: 4.2 MB). - Kyiv: KPI named after Igor Sikorskyi, 2022. - 179 p. Access mode: https://ela.kpi.ua/handle/123456789/48628

2. MCDONALD, John D. Electric power substations engineering . CRC Press , 2016.

3. NAG, PK Power plant engineering . Tata McGraw-Hill Education , 2002.

4. DRBAL, Larry ; WESTRA, Kayla ; BOSTON, Pat (ed .). Power plant engineering . Springer Science & Business Media , 2012.

Educational content

5. Methods of mastering an educational discipline (educational component)

Lecture classes

No s/p	*The name of the topic of the lecture and a list of main questions (list of didactic tools, links to information sources)*
1	*The purpose and tasks of the credit module "Electrical part of stations and substations" and its place among the disciplines of the specialty. General information about the stages of development of the electric power industry of Ukraine. Simplified scheme of the energy system of Ukraine, basic definitions.* *literary sources: lecture notes (KL), L1, p. 5-14. L3, p. 13-16, p. 82-84.* *distance course " Electrical part of stations and substations "* *https://do.ipo.kpi.ua/course/view.php?id=580*
2	*Production of electrical energy at solar and wind power stations. Problems of variability of their operating mode, systems of industrial storage of electrical energy.* *literary sources: KL; L1, p. 39-46; L3, p. 33-41, 74-76.* *distance course " Electrical part of stations and substations "* *https://do.ipo.kpi.ua/course/view.php?id=580*

3	*Production of electrical energy at biogas and hydroelectric power stations. The impact of electricity production on the environment.* *literary sources: KL; L3, p. 16,17; with. 92-97.* *distance course " Electrical part of stations and substations "* *https://do.ipo.kpi.ua/course/view.php?id=580*
4	*Definition of concepts of loss of power and electricity, ways to reduce them, advantages of distributed generation systems. Ways of ensuring power balance in the UES by type of power plants.* *literary sources: KL, L1, p. 51-60; L3, p. 93-98, L1, p. 62-64; L3, p. 100-103* *distance course "Electrical part of stations and substations"* *https://do.ipo.kpi.ua/course/view.php?id=580*
5	*Power quality indicators, load schedules of electrical installations, their types and purpose. Ways of ensuring power balance in the UES by type of power plants. The electrical part of power plants (requirements for it and its components), conventional designations of elements.* *literary sources: KL, L1, p. 51-60; L3, p. 93-98, L1, p. 62-64; L3, p. 100-103* *distance course "Electrical part of stations and substations"* *https://do.ipo.kpi.ua/course/view.php?id=580*
6	*Types, parameters, characteristics and features of synchronous generator designs (SG). Systems that ensure the operation of SG.* *literary sources: KL, L1, p. 60-62; L3, p. 93-98, L1, p. 65; L3, p. 103-104* *distance course "Electrical part of stations and substations"* *https://do.ipo.kpi.ua/course/view.php?id=580*
7	*Power transformers: design features and main parameters. Schemes and groups of winding connections. Cooling systems of power transformers. Parallel work* *Autotransformers, design features and modes of operation. MKR-1.* *Literature: KL, L1, p. 92-98; L3, p. 136-139.* *distance course "Electrical part of stations and substations"* *https://do.ipo.kpi.ua/course/view.php?id=580*
8	*Types of short circuit (short circuit). Transient process with a three-phase short-circuit in a circuit with a source of unlimited power. Practical methods of calculating the three-phase short-circuit current. Algorithm for calculating the three-phase short-circuit current. Determination of the initial value of the periodic short-circuit current, as well as the values of aperiodic and shock currents of the short-circuit.* *literary sources: KL, L1, p. 121-154; L2, p. 101-111; L3, p. 144-157.* *distance course "Electrical part of stations and substations"* *https://do.ipo.kpi.ua/course/view.php?id=580*
9	*Determination of the periodic component of the short-circuit current at a given time. Method of typical curves, example. Electrodynamic effect of short-circuit current Determination of electrodynamic stability of electrical devices. Thermal effect of short-circuit current Determination of thermal stability of electrical devices. Thermal pulse of quadratic current and its application for testing thermal stability.* *literary sources: KL, L1, p. 151-154, L2, p. 112-115, L1, p. 182-193; L3, p. 258-260, p. 269-275.* *distance course "Electrical part of stations and substations"* *https://do.ipo.kpi.ua/course/view.php?id=580*
10	*Methods and means of limiting short-circuit currents. Busbar sectioning, current-limiting reactors (single and double), transformers with splitting of low-voltage windings.* *literary sources: KL, L1, p. 193-202; L3, p. 247-252.* *distance course "Electrical part of stations and substations"* *https://do.ipo.kpi.ua/course/view.php?id=580*
11	*Electrical devices up to 1 kV: breakers, switches, automatic switches, contactors, magnetic starters, fuses. Fuses more than 1kV. High-voltage load and power switches, disconnectors, separators , short-circuits. Current and voltage measuring transformers; purpose, types, designs,*

	accuracy classes. Arresters and their characteristics. Protection of electrical equipment from overvoltage. *literary sources: KL, L1, p. 348-361; L3, p. 252-258, p. 275-286.* *distance course "Electrical part of stations and substations"* *https://do.ipo.kpi.ua/course/view.php?id=580*
12	*Requirements for electrical connection schemes of power plants. Structural diagram of power output. Diagrams of switchgears (RU), their scope of application and comparison on different types of ECs. Simplified RU schemes, bridge schemes.* *literary sources: KL, L1, p. 380-388, 402-408; L2, p. 52-60.* *distance course "Electrical part of stations and substations"* *https://do.ipo.kpi.ua/course/view.php?id=580*
13	*Schemes of rings (polygons). Schemes with a bypass bus system (with one working bus system and two). Scheme with two systems of working buses without a bypass (fixed connection of connections). Schemes with connection switching through two switches (schemes 3/2 and 4/3). Fields of application of various schemes and their comparison.* *literary sources: KL, L1, p. 413-417; L3, p. 313-317.p. 408-413; L3, p. 311-313.* *distance course "Electrical part of stations and substations"* *https://do.ipo.kpi.ua/course/view.php?id=580*
14	*Peculiarities of choosing communication transformers at one- and two-transformer substations.* *literary sources: KL, L1, p. 417-420; L3, p. 320-323, p. 420-426; L3, p. 317-320.* *distance course "Electrical part of stations and substations"* *https://do.ipo.kpi.ua/course/view.php?id=580*
15	*Classification of substations. Schemes of nodal, through, branching and dead-end substations. Schemes of substations on the example of wind, solar and bioenergy power stations.* *literary sources: KL, L1, p. 568-579; L2, p. 186-203; L3 p. 411-430.* *distance course "Electrical part of stations and substations"* *https://do.ipo.kpi.ua/course/view.php?id=580*
16	*Schemes of electrical connections of own needs (VP), features of their arrangement at different types of electrical stations. VP power sources.* *literary sources: KL, L1, p. 437-443; L3, p. 331-337.* *distance course "Electrical part of stations and substations" lecture 16* *https://do.ipo.kpi.ua/course/view.php?id=580*
17	*Characteristics and modes of operation of electrical energy storage systems.* *Self-starting of the VP electric drive and its role in increasing the reliability of power plant operation.* *literary sources: KL, L1, p. 568-579; L2, p. 186-203; L3 p. 411-430.* *distance course "Electrical part of stations and substations" lecture 17* *https://do.ipo.kpi.ua/course/view.php?id=580*
18	*Measurement, control and signaling subsystems. Requirements for schemes of remote control of switching devices. Simplified schemes of remote control of switches with an electromagnetic drive. Purpose of relay protection.* *literary sources: KL, L3, p. 442-450, p. 459-466, p. 472-476, p. 484-490.* *distance course "Electrical part of stations and substations" lecture 18* *https://do.ipo.kpi.ua/course/view.php?id=580*

6. Student's independent work

No s/p	*Type of independent work*	*Number hours of SRS*
1	*Production of electrical energy at solar and wind power stations. Problems of variability of their operating mode, systems of industrial storage of electrical energy*	*2*

2	*Production of electrical energy at biogas and hydroelectric power stations. The impact of electricity production on the environment.*	*2*
3	*Thermal pulse of quadratic current and its application for testing thermal stability.*	*2*
4	*Current and voltage measuring transformers; purpose, types, designs, accuracy classes. Arresters and their characteristics. Protection of electrical equipment from overvoltage.*	*1*
5	*Preparation for laboratory classes*	*12*
6	*Preparation for lectures*	*9*
7	*Preparation for MKR*	*2*
8	*Preparation for the exam*	*30*
	In total	*66*

Modular control work

According to RSO, 1 modular control work is planned for the training period in accordance with the sections: Basic information about energy systems and stations; Basic electrical equipment of power plants and short-circuit currents and selection of electrical devices. The modular test contains 14 questions, each question (task) is valued at 1 point. The modular control work is performed in the Moodle environment . The MKR weighted score is 14 points.

Policy and control

7. Policy of academic discipline (educational component)

The system of requirements that the teacher sets before the student:

- *the class attendance rule does not provide for the assessment of the student's presence or absence in the classroom class, including the awarding of incentive or penalty points. Completion and defense of laboratory works in the discipline is a mandatory condition for admission to the exam;*
- *the student has the opportunity to receive points for the appropriate types of educational activity provided for by the RSO of the discipline. The use of means of communication to search for information on the Internet and distance course on the Sikorsky platform is carried out under the condition of the instruction of the teacher;*
- *rules for the protection of laboratory work: both individual protection of laboratory work and collective protection (as part of a team, the composition of which is determined at the first laboratory session) are allowed. In both cases, the individual answers of each student are evaluated. In the conditions of distance learning, the defense of laboratory work is carried out by taking a test on the content of LR;*
- *rules for assigning incentive points : incentive points are not included in the main scale of RSO, and their sum does not exceed 10% of the starting scale. Incentive points are awarded for completing additional tasks and independent study of additional sections.*
- *policy of deadlines and rescheduling: if a student did not pass or did not appear at the MKR, his result is evaluated at 0 points. There is no provision for rescheduling the defense of laboratory work and MKR results;*
- *policy on academic integrity: the Code of Honor of the National Technical University of Ukraine "Kyiv Polytechnic Institute" https://kpi.ua/files/honorcode.pdf establishes general moral principles, rules of ethical behavior of individuals and provides a policy of academic integrity for persons working and studying at the university, which they should be guided by in their activities, including when studying and preparing control measures in the discipline "Electrical part of stations and substations";*
- *when using digital means of communication with the teacher (mobile communication, e-mail, correspondence on forums and social networks , etc.), it is necessary to observe generally accepted ethical norms, in particular, be polite and limit communication to the working hours of the teacher.*

8. Types of control and rating system for evaluating learning outcomes (RSO)

Current control *: implementation of MKR, implementation and protection of laboratory work.*
Calendar control *: conducted twice a semester as a monitoring of the current state of meeting the syllabus requirements .*
Semester control *: exam*
Conditions for admission to semester control *: enrollment of all laboratory work, semester start rating (R_S) more than 25 points.*
Table of correspondence of rating points to grades on the university scale:

Number of points	*Rating*
100-95	*Perfectly*
94-85	*Very good*
84-75	*Good*
74-65	*Satisfactorily*
64-60	*Enough*
Less than 60	*Unsatisfactorily*
Admission conditions not met: no $R_{L\ received}$ $R_S=R_L+R_M<25$ points	*Not allowed*

The student's overall rating after the end of the semester consists of points obtained for:

- *performance and protection of laboratory work (R_L);*
- *execution of modular control work (MKR) ($RM_)$*
- *exam answers (R_E).*

Laboratory work (R_L)	*MKR ($RM_)$*	*Exam (R_E)*
36	*14*	*50*

Laboratory work

Weight score. All laboratory works have a weighting point of 2. *The maximum number of points for all laboratory works is 4*9=36 points.*

In laboratory work, students study the parameters and characteristics of certain high-voltage electrical equipment according to a predetermined schedule. For admission to the current laboratory work, the student must have a protocol, which is drawn up in accordance with the instructions of the laboratory practice. The level of assimilation of laboratory work is assessed using an online test on the course platform, consisting of 10 questions and valued at 0.2 points each.

WARNING! *Defense of all laboratory work is a condition for admission to the exam. Students who, at the time of the consultation before the exam, have not defended the laboratory work, are not allowed to take the main exam and are preparing for a retake.*

WARNING! *In order to be allowed to retake the exam, it is necessary to pay all debts for laboratory work by the deadline set by the teacher.*

Modular control work

During the training period, 1 modular control work is planned according to the sections: Basic information about energy systems and stations; Basic electrical equipment of power plants and short-circuit currents and selection of electrical devices. The modular test contains 14 questions, each question (task) is valued at 1 point. The MKR weighted score is 14 points.

MKR evaluation criteria

Each question of the test is formed using the material of the lectures and contains four answer options. There is only one correct answer. The testing takes place within 30 minutes, there are no scheduled MKR retakes.

Calendar control

The condition for a positive first attestation is to obtain at least 10 points and perform all laboratory work (at the time of attestation). The condition for a positive second certification is to obtain at least 15 points and perform all laboratory work (at the time of certification).

The maximum rating for the semester is determined with the expression:

$$R_S = R_L + R_M = 36+14=50 \text{ points}$$

Additional points

The rating system provides points for completing additional tasks. One student cannot receive more than 5 bonus points in a semester. Bonus points can be obtained for completing additional tasks and lectures.

Additional tasks and lectures

*Additional lectures are topics for independent study, which will provide students with a strengthening of theoretical knowledge of the discipline. The weighted score is 0.5. The maximum number of points for studying additional lectures is 0.5 points * 10 lectures = 5 points. Winners receive points for uploading a synopsis of the prepared lecture to the Moodle system*

The form of semester control is an exam

The condition for admission to the exam is the enrollment of all laboratory work, modular control work and a semester rating of at least 25 points.

At the exam, students perform exam work in the form of a two-level test.

*A simple test containing 15 questions, 2 points each (maximum score 15*2=30 points). Compilation of a simple test is aimed at checking the knowledge acquired as a result of studying the educational component of students in the form of testing based on the lecture material of the semester. Each theoretical test task of the ticket is evaluated with 1 point, and the practical task with 5 points, based on the following criteria:*

0 – the choice of the answer option is incorrect or more than one answer option is selected;

2 – the correct answer option is selected.

*A complex test containing 4 practical questions (problems) of 5 points each (maximum score 5*4=20 points). Answer options are given at the end of the task.*

Criteria for awarding points for a practical calculation task (task):

0 – the problem was not solved, or formulas were used with gross errors, or as such, which are not relevant to the essence of the problem;

1 – the problem was solved, but in the end there is no answer and only general formulas and considerations are given in the solution or gross errors were made in the use of formulas;

2 – the problem was solved, the correct answer was indicated, but only the most general formulas and considerations were given;

3 – the problem is solved in a general form, the correct answer is indicated, but it contains gross errors in calculations;

4 – the problem is solved mainly correctly, but without appropriate explanations, or a minor error (inaccuracy) is made;

5 – the problem is solved correctly with appropriate explanations.

The sum of the starting points and the points for the examination work is transferred to the final grade according to the table:

$$R = R_S + R_E = 50 + 50 = 10\ 0 \text{ points}$$

Number of points	Rating
100-95	Perfectly
94-85	Very good
84-75	Good
74-65	Satisfactorily
64-60	Enough
Less than 60	Unsatisfactorily
There are uncredited laboratory works	Not allowed

9. Additional information on the discipline (educational component)

List of topics that are submitted for semester control

1. *General information about the electric power system*
2. *Production of electrical energy by types of electrical plants (bio- , wind- , hydro-, and solar).*
3. *Prospects for the development of renewable energy.*
4. *Indicators of the quality of electric energy*
5. *Graphs of electrical loads*
6. *Operational maintenance of the balance of electricity generation and consumption in the UES*
7. *General characteristics of the electrical part of the power plant*
8. *Synchronous generators. General information*
9. *Cooling systems of synchronous generators*
10. *Excitation systems of synchronous generators*
11. *Parallel operation of generators*
12. *Power transformers and autotransformers. General information*
13. *Parallel operation and groups of transformer connections*
14. *Cooling of transformers*
15. *Autotransformers*
16. *Processes of switching off electrical circuits of alternating current*
17. *Volt-ampere characteristics of the arc*
18. *High voltage AC circuit breakers*
19. *Disconnectors, dividers and short circuits*
20. *Load switches*
21. *Devices with a voltage of up to 1000 V*
22. *Current limiting reactors*
23. *Measuring devices*
24. *Conductors and insulators*
25. *Short circuits in electrical installations. General information*
26. *Three-phase short-circuit in a circuit with a source of limited and unlimited power*
27. *Calculation of short circuit current.*
28. *Purpose and procedure for performing calculations*
29. *Calculation and alternate schemes*
30. *Bringing resistances of circuit elements to basic conditions*
31. *Converting the proxy scheme to its simplest form*
32. *Determination of the initial value of the periodic component of the SKZ*
33. *Calculation of the periodic component of the SKZ at an arbitrary moment in time*
34. *Method of typical curves*
35. *Calculation of the aperiodic component and shock current of the short circuit*
36. *Peculiarities of calculating short-circuit currents in the system of own needs of an electric station*
37. *Thermal and electrodynamic effect of SCZ*
38. *Methods of limiting SCZ*
39. *Electrical diagrams of stations and substations. Basic definitions*
40. *Structural schemes of electricity supply*
41. *Elements of the main schemes*
42. *Electrical schemes of switchgear. Schemes of RU GN (6-10kV)*
43. *Schemes of switchgear at high voltage.*
44. *Schemes with a bypass SS*
45. *Ring diagrams. Schemes of polygons*
46. *Schemes of bridges*
47. *Scheme "3/2" (one and a half) and "3/4"*
48. *Selection of transformers in power station schemes*

49. *Main schemes of substations*
50. *Characteristics and modes of operation of electrical energy storage systems.*
51. *Schemes of substations on the example of wind, solar and bioenergy power stations.*
52. *Own needs of power plants*
53. *VP power sources. Peculiarities of the organization of the system of own needs at power plants of various types*
54. *Self-starting asynchronous motors*
55. *Remote control of switches*
56. *Remote control of air switches*
57. *Alarm system on the control panel (PCB)*

Working program of the academic discipline (syllabus):

Compiled *by a professor of the Department of Renewable Energy Sources of the FEA , Ph.D. Ostapchuk O.V.*

Approved *by the Department of Renewable Energy Sources of the FEA (protocol No. 14 dated 05/24/2024)*

Agreed by *the Methodical Commission of the faculty* [1] *(protocol No. 10 dated 06/20/2024)*

[1] Methodical council of the university – for general university disciplines.