

Документ подписан Системой Электронной Подписи
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Federal State Autonomous Educational Institution of Higher Education "Patrice Lumumba Peoples' Friendship University of Russia
"Peoples' Friendship University of Russia named after Patrice Lumumba"
Engineering Academy

(educational division (faculty/institute/academy) as programme developer)

Department "Power Engineering"

(department realizing the PhD program)

COURSE SYLLABUS

Power systems and complexes

(course title)

Scientific speciality:

2.4.5 Energy systems and complexes

(scientific speciality code and title)

The course instruction is implemented within the PhD programmes:

Energy systems and complexes

(PhD program title)

2026 г.

1. DISCIPLINE (MODULE) GOAL

The purpose of the discipline is the study and research of relations and regularities in the field of calculations of optimal parameters and modes, design, control, installation and operation of power units, power plants and energy complexes based on renewable energy sources (RES) and preparation of a postgraduate student to pass the candidate examination.

The objectives of the discipline are:

- formation of skills and in the field of theory and practice of energy systems and complexes;
- study of the main methods of scientific research applied in this field;
- mastering of key approaches to the study of objects of energy systems and complexes.

2. REQUIREMENTS TO PHD-STUDENTS ON FINISHING THE COURSE

Mastering the discipline "Energy systems and complexes" is aimed at preparation for passing the candidate examinations, as well as mastering the competences:

- Possession of the methodology of theoretical and experimental research in the field of energy systems and complexes;
- possession of the culture of scientific research in the field of energy systems, including the use of the latest information and communication technologies;
- ability to develop new research methods and their application in independent research activities in the field of RES-based power installations, taking into account the rules of copyright;
- readiness to develop devices and technologies contributing to the improvement, optimisation and increase of operational reliability, environmental safety of RES-based power units, methods of their calculation and design;
- ability to create and develop effective methods of calculation and experimental research of power units based on RES.

As a result of studying the discipline the student should:

- Know:** - device of hydraulic, solar and wind power installations of different types;
- energy characteristics of hydraulic, solar and wind power plants of different types and the influence of external factors on them;
 - peculiarities of operation of power plants based on RES;
 - peculiarities of design, management, installation and operation of power units, power plants and energy complexes based on RES.

Be able to: carry out theoretical and experimental research in the field of power engineering: - master the methods of combining RES-based power units into power complexes; - master the methods of integrating RES-based power units into power systems.

- Possess:** - methods of calculation of optimal parameters and composition of equipment of power plants and power complexes based on RES;
- methods of calculation of optimal modes of operation of power units, power plants and energy complexes based on RES.

3. WORKLOAD OF THE DISCIPLINE AND TYPES OF ACTIVITIES

The total labour input of the discipline "Energy systems and complexes" is 3 credit units.

Table 3.1. Types of academic work by periods of mastering the postgraduate programme

Type of academic work	TOTAL , ac.h.	semester
		3
<i>Contact work, ac.h.</i>	18	18
including:		
Lectures (LK)	30	30
Practical/seminar classes (SP)	30	30
<i>Independent work of students, ac.h.</i>	48	48
<i>Control (credit with evaluation), ac.h.</i>		
Total labour input of the discipline	ac.h.	108
	credit units.	3

4. CONTENT OF THE DISCIPLINE

Table 4.1. Content of the discipline (module) by types of academic work

No. n/a	Name of the discipline section	Content of the section (topic)
1.	Introduction.	Sources of renewable energy and their peculiarities. Geography of energy resources.
2.	Section No. 1. Renewable types of energy and energy installations based on them.	Topic 1.1. Basic concepts and definitions in the practice of research and utilisation of renewable energy types (RES). Modern information support for RES resources assessment. RES parameters and methods of their measurement. Main categories of RES potentials and methods of their calculation. Current state and prospects of RES utilisation. Place and significance of RES in the modern fuel and energy complex of the world and Russia. Technical peculiarities of RES use in centralised and decentralised energy supply systems. Economic aspects of RES utilisation.
3.	Section No. 2. Models and technologies of using solar energy units.	Topic 2.1. Sources of solar energy potential. Solar radiation: direct and diffuse. Spectra of extra-atmospheric and terrestrial solar radiation. Methods of measuring solar radiation. Methods of calculating the arrival of solar radiation to an arbitrarily orientated area at an arbitrarily taken point on the Earth's surface. Dependences of solar radiation on the time of year and latitude of the terrain. Absorption in the atmosphere (optical mass). Optimal orientation of a solar radiation receiver. Topic 2.2. Main categories of solar energy potential and methods of their calculation. Solar energy cadastre. Main types of solar energy units (SEU) and stations (SES): power supply, hot water supply, heating, cooling, drying, desalination, hydrolysis, etc. Tower SESs. Basic technological scheme, its components and energy characteristics. Equation of motion of the Sun and heliostats. Shading and blocking of heliostats. Coefficient of

		<p>solar radiation capture by the receiver. Thermal receiver and methods of its calculation. Optimisation of the system "concentrator (heliostats) - receiver".</p> <p>SES on the basis of solar ponds. Technological scheme of energy conversion and its components. Thermal gradient. Heat storage characteristics of solar ponds. Calculation methods of the main parameters of solar pond-based SES.</p> <p>SES with parabolic and parabolocylindrical concentrators: technological scheme of energy conversion and its components. Effect of radiation concentration. Calculation methods of the main parameters.</p> <p>Topic 2.3. Photovoltaic SES. Photovoltaic power generation. Structure of solar cells and principles of their operation. Photovoltaic circuit and load properties of photovoltaic cells. Main types of energy losses and factors affecting the efficiency of a photovoltaic cell. Constructions of solar cells. Basic technical requirements for solar cell materials. Rigid and flexible photocells. Radiation concentrators, their varieties and peculiarities of use. Efficiency factor of the main types of photovoltaic cells. Photovoltaic power stations.</p> <p>Solar collectors and their varieties. Principle of operation, main design features, efficiency of solar collectors. Calculation of temperature field of heat losses, heat removal, optical efficiency Selective coatings their varieties and properties.</p> <p>Stages of designing SEU and SES. Selection and justification of construction sites. Selection and justification of the type and main parameters of SES.</p> <p>Operational features and modes of different types of terrestrial and space SES. Reliability of their operation. Technical and economic indicators of the operation of power plants and SES.</p>
4.	<p>Section No. 3. Models and technologies of wind power plants.</p>	<p>Topic 3.1. Sources of wind energy potential. Basic characteristics of wind and methods and definitions. Short-term variations of wind speed: turbulence, wind gustiness. Maximum wind speed. Energy characteristics of wind: power and energy. Influence of terrain orography on wind formation: terrain roughness, land surface shapes, obstacles. Methodological basis for assessing the influence of the earth's surface on wind speed. Vertical wind profile. Characteristic wind distribution functions (Rayleigh, Weibull, Grintsevich, etc.). Wind rose. Weathercock height. Geographical factors and local estimated wind parameters. Main categories of wind energy potential and methods of their calculation. Wind energy cadastre. Main technical schemes of wind energy utilisation and their classification.</p> <p>Wind energy transformation (elements of aerodynamics). Theory of ideal and real wind engine. Axial and lifting force, operating torque and power. Energy losses. Methods of obtaining energy characteristics of a wind wheel. Methods of mounting a wind wheel to the wind. Forces acting on the wind wheel during its operation in the oblique flow Gyroscopic moment of the wind wheel. Methods of regulating the wind wheel speed and its power.</p> <p>Topic 3.2. Design features and energy characteristics of the main elements of a wind power plant (WPP). Operation modes</p>

		<p>of a wind wheel. Fast speed and its relation to the power factor. Approached and useful power of a wind turbine. Main types of energy losses. Wind turbines designed for the production of electricity, heat, mechanical energy and their peculiarities.</p> <p>Wind turbines with horizontal axis of rotation. Main elements of construction. Single- and multi-blade wind turbine systems with stabilisers, without it or with additional side wheel, with servo motor or with selforientation. Peculiarities of wind turbine operation modes.</p> <p>Wind turbines with vertical axis of rotation. Main elements of construction. Main types of wind turbines. Energy characteristics of wind turbines of different types with vertical axis of rotation.</p> <p>Topic 3.3. Energy balance of wind turbines. Main energy characteristics. Air flow concentrators, design features, efficiency.</p> <p>Wind power engineering standards. Stages of wind power plant design. Selection of a site for wind power plant location. Wind monitoring. Criteria for selecting wind turbine equipment. Safety classes of wind turbines. Climatic execution of wind turbines. Criteria of energy efficiency of wind turbines. Transport and installation of wind turbines.</p> <p>Wind power station. Schemes of optimal placement of wind turbines in relation to each other and to the wind flow taking into account the wind rose. Shading effect.</p> <p>Functional elements of the control system. Requirements to control and protection systems. Operating modes of wind turbines. Electromechanical transients in wind turbines. Modelling of WPP operation modes.</p>
5.	<p>Section No. 4. Models and technologies of using power units based on hydraulic energy.</p>	<p>Topic 4.1. Sources of hydropower potential: natural and artificial watercourses, reservoirs, hydraulic engineering systems, glaciers, underground water, tides, waves and currents in seas and oceans. Basic hydraulic and energy parameters of sources of large and small hydropower (SHP) potential. Methods of head and flow measurement. Hydrometric characteristics of the source of potential. Hydrological information and its peculiarities for MGE. Use of deterministic and probabilistic calculation methods in hydrology. Peculiarities of catchments and drainages formation.</p> <p>Topic 4.2 Energy of sea waves and currents. Sources of potential and their peculiarities. Surface waves on deep and shallow water (basics of wave motion theory). Wave energy and power and methods of its utilisation. Ideal and real waves and methods of their description. Energy spectrum (wave power distribution) of waves. Methods of utilising wave energy in continuous wave motion. Distribution of wave potential.</p> <p>Tidal energy. Sources of potential and their peculiarities. Tides in the open ocean and near coasts. Tidal wave. Energy of tidal currents and methods of its calculation. Main characteristics of tidal wave and features of their change in time and from the main influencing factors, methods of their calculation. Geography of tides.</p>

		<p>Topic 4.3. Main categories of small hydropower potential (including waves and tides) and methods of their calculation. Input-energy cadastres of hydropower.</p> <p>Small hydropower plants (SHPPs) and hydroelectric power plants (HPPs) of different types.</p> <p>Small hydropower plants (SHPP): classification features. Main methods and ways of head and water flow concentration. The main types and kinds of turbines of MHPS, their energy characteristics, methods of obtaining. Water-supply and water-diverting structures of MGES and their energy characteristics. Non-traditional schemes and types of equipment of MHPS.</p> <p>Main types of hydroelectric generators of MHPPs. Energy characteristics of hydrogenerators. Methods of selection and justification of the main parameters of hydropower units of MHPS.</p>
6.	Section No. 5. Energy storage	<p>Topic 5.1. Purpose of energy storage and principles of their storage: biological, chemical, thermal, electrical, mechanical. Main characteristics.</p> <p>Energy storage units (EACU) and stations (EACS). Hydroaccumulating, thermal, inductive, hydrogen and other types of energy accumulation. Technological cycles of EACU and principle of their operation. storage efficiency. Basic energy characteristics, methods of their obtaining and calculation. Depth and rate of charge-discharge. Storage cycle duration. Guaranteed number of charge-discharge cycles. Energy converters of EACU.</p>
7.	Section No. 6. Basic technical schemes of renewable energy conversion.	<p>Topic 6.1. Basic energy characteristics of energy conversion. Methods of calculation and measurement of basic parameters and characteristics in steady-state and transient modes.</p> <p>Power complexes (EC). Basic schemes of EC, principles of their operation for autonomous consumers and united power system. Calculation methods of the basic energy parameters of EC with energy accumulators of different types.</p> <p>Main stages of designing schemes of plants and stations on the basis of VVER. Initial information, methods of its obtaining and storage. Parameters of power units and methods of their calculation.</p> <p>Calculation of short-term and long-term operation modes of power units on the basis of different WWE under deterministic, probabilistic and uncertain information for justification of their design parameters. Problem statements, solution methods, basic assumptions.</p> <p>Optimisation of the structure of generating capacities of local and united power systems with power units on the basis of WWE.</p>

5. EQUIPMENT AND TECHNOLOGY SUPPORT REQUIREMENTS

Table 5.1. Material and technical support of the discipline

Classroom type	Classroom equipment	Specialised training/laboratory equipment, software and materials for mastering the discipline (if necessary)
Lecture room	Auditorium for lecture-type classes, equipped with a set of specialised furniture; blackboard (screen) and technical means of multimedia presentations.	projector, screen, computer, chalk board
Seminar room	Auditorium for seminar-type classes, group and individual consultations, current control and interim certification, equipped with a set of specialised furniture and technical means of multimedia presentations.	projector, screen, computer, chalk board.
For independent work of students	Auditorium for independent work of students (can be used for seminars and consultations), equipped with a set of specialised furniture and computers with access to EIOS.	projector, screen, computer, chalk board

6. METHODOLOGICAL SUPPORT AND LEARNING MATERIALS

The main readings:

1. Wind power engineering: textbook / O. Y. Sigitov, Y. A. Radin. - Moscow: PFUR, 2024. - 138 c.
2. Chubais, A.B.; Zubakin, V.A.; Kopylov, A.E. Development of renewable energy in Russia: technologies and economy. - Moscow: Publishing Group "Tochka", 2020.
3. Wind Energy Explained: Theory, Design and Application J. F. Manwell, J. G. McGowan, A. L. Rogers. 2009. ISBN: 0470015004

Additional readings:

1. Basic wind characteristics. Wind resources and methods of their calculation: textbook / Deryugina G.V., Malinin N.K., Pugachev R.V., Shestopalova T.A. - Moscow: MPEI Publishing House, 2012.
2. Tsgoev R.S. Non-traditional wind power engineering. Textbook / - Moscow: MPEI Publishing House, 2014.
3. Methods of calculation of renewable energy resources. Textbook / Burmistrov A.A., Vissarionov V.I., Deryugina G.V., Kuznetsova V.A., Kunakin D.N., Malinin N.K., Pugachev R.V. - Moscow: MPEI Publishing House, 2nd edition, 2007, 144 p.
4. Solar power engineering. Textbook / V.I. Vissarionov, G.V. Deryugina, V.A. Kuznetsova, N.K. Malinin - Moscow: MPEI Publishing House, 2008, 276 p.
5. Aldo V. da Rosa. Renewable sources of energy. Physico-technical bases. Textbook. - M.: Media Format Publishing House, 2010. - 704 c.
6. Hydro-storage power stations in modern electric power engineering. / Sinyugin V.Yu., Magruk V.I., Rodionov V.G., Moscow: NTs ENAS Publishing House, 2008.
7. Sibikin Yu.D., Sibikin M.Yu. Non-traditional and renewable energy sources: textbook. - Moscow: KHOPYC, 2010.
8. Elistratov V.V. Utilisation of renewable energy: textbook, CP6: Izd-vo Polytechnicheskiiy Usta, 2010. - 224 c.
9. Reference materials for course and dirilomnogo design of hydropower installations. / A.Yu. Aleksandrovskiy, B.I. Silaev, met. manual. - Moscow: MPEI Publishing House, 2007.
10. Aleksandrovskiy, A.Yu.; Silaev, B.I. Justification of the parameters of the designed hydroelectric power plant, Methodical manual for the course. MPEI Publishing House, 2006.
11. Hydropower Engineering. 2nd edition, revision and addendum / Edited by V.I. Obrezkov. Moscow: Energoatomizdat, 1988.
12. Hydroelectric power stations / Edited by V.Ya. Karelin and G.I. Krivchenko. Moscow: Energoatomizdat, 1987.
13. Vissarionov V.I., Zolotov L.A. Ecological aspects of renewable energy sources. Moscow: MPEI Publishing House, 1996.
14. Energy Accumulators / Edited by D.A. Buta. Moscow: Energoatomizdat, 1991.
15. Vasiliev Yu.S., Kharitonov N.I. Ecology of Renewable Energy Sources Utilisation. L.: LSU, 1991.
16. Water-Energy and Water Management Calculations / Edited by V.I. Vissarionov. Moscow: MPEI Publishing House, 2001.

Resources of information-telecommunication network "Internet":

1. RUDN EBS and third-party EBS to which the University students have access on the basis of concluded agreements:

- PFUR Electronic Library System - PFUR EBS

<http://lib.rudn.ru/MegaPro/Web>.

- EBS "University Library Online" <http://www.biblioclub.ru>

- EBS Yurait <http://www.biblio-online.ru>

- EBS "Student's Consultant" www.studentlibrary.ru

- EBS "Lan" <http://e.lanbook.com/>
- EBS "Trinity Bridge"

2. Databases and search engines:

- electronic fund of legal and normative-technical documentation
<http://docs.cntd.ru/>
- Yandex search engine <https://www.yandex.ru/>
- Google search engine <https://www.google.ru/>
- abstract database SCOPUS
<http://www.elsevierscience.ru/products/scopus/>

Educational and methodical materials for independent work of students when mastering the discipline/module:*

1. Course of lectures on the discipline "Energy systems and complexes".
2. Methodical recommendations for independent learning


* - all educational and methodical materials for independent work of students are placed in accordance with the current order on the page of the discipline in TUIS!

7. 7. ASSESSMENT TOOLKIT AND GRADING SYSTEM FOR MIDTERM ATTESTATION OF STUDENTS IN THE DISCIPLINE (MODULE)

Assessment toolkit and a grading system to evaluate the level of competences (competences in part) formation as the course results are specified on the TUIS platform.

DEVELOPERS:

**Associate Professor, Candidate of
Technical Sciences,
Department of Power Engineering**



Oshchepkov P.P.

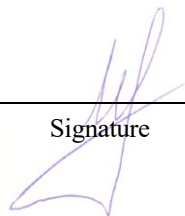
Position, BUP

Signature

Surname I.O.

HEAD OF BUP:

Department of Power Engineering



Radin Yu.A.

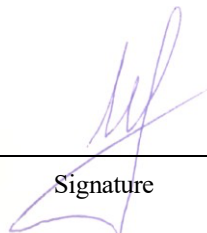
Name of BUP

Signature

Surname I.O.

HEAD OF OP WO:

**Professor, Doctor of Technical
Sciences,
Department of Power Engineering**



Radin Y.A.

Position, BUP

Signature

Surname I.O.