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|  |  | **Кафедра автоматизації електротехнічних та мехатронних комплексів** |
| **Theoretical fundamentals and applied aspects of bioenergy technologies**  **Work program of the discipline (Syllabus)** | | |

# Requisites of the academic discipline

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| --- | --- |
| Degree of higher education | *Second (Master)* |
| Field of study | *14 Electric engineering* |
| Specialty | *141 Electric Power Engineering, Electrotechnics and Electromechanics* |
| Study program  Certificate program | *Engineering of Intellectual Electrotechnical and Mechatronic Complexes*  *Engineering and automation of hydrogen energy systems and technologies* |
| Status of the discipline | *Selective* |
| Form of study | *Full-time/part-time/distance learning* |
| Year of study, semester | *1st year of study/ spring semester* |
| Volume of the discipline | *4 credits 120 hours (36 lectures, 18 practical, 66 SSW)* |
| Semester control/ control activities | *Credit, MCW* |
| Timetable | [*http://rozklad.kpi.ua/*](http://rozklad.kpi.ua/) |
| Language of study | *English* |
| Information about the course leader / teachers | Lecturer: associate professor, PhD, senior researcher, Anna V. Yakovlieva*,*  *tel. +38 063 630 89 59, e-mail: a.v.iakovlieva@lll.kpi.ua[[1]](#footnote-2)*  Practical lessons: *assistant Artmem Khotian,*  *tel. +38 068 546 22 07, email: a.khotian@kpi.ua* |
| Placement of the course | Available on the Google Classroom platform. The access code is provided by the teacher at the first lesson. |
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# Program of the discipline

# Description of the discipline, its purpose, subject matter and learning outcomes

The transition to alternative energy and power sources has become an integral part of the development of modern society in the context of sustainable development. The main task of bioenergy is to provide humanity with affordable, cheap, inexhaustible and safe energy sources. The use of alternative energy sources at stationary facilities and in transport is a way to reduce energy imports and ensure energy independence of the state.

The purpose of studying the discipline is to form the student's theoretical knowledge and practical skills in the field of alternative energy (bioenergy). The study of the material of this discipline is focused on in-depth learning of the basics of the use of biological motor fuels.

# The subject of the discipline is the technological processes of energy production, in particular motor fuels, from biological (renewable) energy resources.

# Program learning outcomes:

# Ability to quantify comparative assessment of different types and sources of energy resources, systems of their use. Ability to build effective systems for the use of energy resources, determine the capacity of the relevant equipment. Ability to select modern technological solutions for the processing of alternative energy resources and the production of high-quality and affordable fuels, including for the transport sector.

# Knowledge of the principles of alternative energy functioning, global development trends and legal regulation of bioenergy facilities. Knowledge of trends and prospects for the development of traditional and alternative energy sources, technologies for the production of bioethanol, biodiesel, biogas, bio-kerosene.

###### **2. Prerequisites and post-requisites of the discipline (place in the structural and logical scheme of study in the relevant educational program)**

# The discipline "Theoretical Fundamentals and Applied Aspects of Bioenergy Technologies" is taught on the basis of the knowledge and skills gained by students during the study of credit modules in such disciplines as Transport Systems of Electromechanical Complexes, Hydraulics and Hydropneumatic Drive, Electrical Machines and Technical Mechanics.

# The knowledge and skills acquired in the course of studying the discipline " Theoretical Fundamentals and Applied Aspects of Bioenergy Technologies " are necessary for specialists in this specialty who solve engineering problems in the field of electricity and electrical engineering and in the study of the disciplines "Fundamentals of Rational Use of Traditional and Alternative Fuel and Energy Resources", "Technical Regulation, Standardization and Certification in Energy", etc.

# 3. Content of the discipline

**Section 1.** Introduction to the course "Theoretical Fundamentals and Applied Aspects of Bioenergy Technologies":

Topic 1.1. General concepts of bioenergy and sustainable development, classification of energy sources.

Topic 1.2. Prospects for the development and greening of the fuel and energy complex.

Topic 1.3. Economic and legal aspects of bioenergy development

**Section 2:** Theoretical foundations and applied aspects of motor fuels production from renewable raw materials:

Topic 2.1. Technologies for the production and use of biofuels for stationary installations.

Topic 2.2: Technologies for the production and use of biofuels for vehicles.

**Section 3.** Theoretical foundations and applied aspects of the use of hydrogen as an energy source:

Topic 3.1: Use of hydrogen in vehicles.

# 4. Навчальні матеріали та ресурси

**Basic literature:**

1. Efstathios E. (Stathis) Michaelides. 2012. Alternative Energy Sources. Springer Berlin, Heidelberg, 462 р. [Alternative Energy Sources | SpringerLink](https://link.springer.com/book/10.1007/978-3-642-20951-2#bibliographic-information)

2. Mariano Martín. 2016. Alternative Energy Sources and Technologies. Springer Cham. 512 р. [Alternative Energy Sources and Technologies: Process Design and Operation | SpringerLink](https://link.springer.com/book/10.1007/978-3-319-28752-2#book-header)

### 3. Sharlissa Moore. 2018. **Sustainable Energy Transformations, Power And Politics: Morocco And The Mediterranean (Routledge Studies In Energy Transitions) 1st Edition. 260 р.**

# 4. John Twidell, Tony Weir. 2015. Renewable Energy Resources. Routledge. 784 р. [Renewable Energy Resources: Amazon.co.uk: Twidell, John, Weir, Tony: 9780415584388: Books](https://www.amazon.co.uk/dp/0415584388?linkCode=gs2&tag=smbb0a-21)

# 5. Andrzej L. Wasiak. 2021Alternative Energy Sources. MDPI. 234 р. [Alternative Energy Sources | MDPI Books](https://www.mdpi.com/books/book/3738-alternative-energy-sources)

6. Nicholas Jenkins , Janaka Ekanayake. 2017. Renewable Energy Engineering Cambridge University Press. [Renewable energy engineering | Energy technology | Cambridge University Press](https://www.cambridge.org/sk/universitypress/subjects/engineering/energy-technology/renewable-energy-engineering?format=HB&isbn=9781107028487)

**Additional literature:**

1. Yakovlieva A.V. Modification of jet fuels composition with renewable bio-additives / A.V. Yakovlieva, S.V. Boichenko, K. Lejda, O.O. Vovk. K.: National aviation university, 2019. – 207 p.

5. Fundamentals of Chemmotology [Electronic resource] : manual / S. V. Boichenko, A. V. Yakovlieva, O. O. Vovk, M. M. Radomska, L. M. Cherniak, I. O. Shkilniuk ; National Aviation University. – Kyiv, 2019. – 296 p. <https://ela.kpi.ua/handle/123456789/49653>

# *The literature, the bibliography of which is given with a reference, can be found on the Internet. Literature that does not contain references can be found in the library of Igor Sikorsky Kyiv Polytechnic Institute. Some sections of the basic literature [1]-[5] are required reading. The sections of the basic literature that are required for reading, as well as the relationship of these resources to specific topics of the discipline, are given below in the methodology for mastering the discipline. All other literary sources are optional and are recommended to be read*

# Educational content

# 5. Methods of mastering the discipline (educational component)

Active learning strategies are applied, which are determined by the following methods and technologies: problem-based learning methods (research method); personality-oriented technologies based on such forms and methods of teaching as case technology and project technology; visualization and information and communication technologies, including electronic presentations for lectures. The methodology of teaching the discipline combines visual teaching methods with explanation. Teaching is conducted in the form of lectures, laboratory and practical classes. The problem-solving method is used in the calculation work.

**Lectures**

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| --- | --- |
| No | Title of the lecture topic and a list of key issues (references to literature) |
| 1 | **Lecture 1.** Topic 1.1 General concepts of bioenergy and sustainable development. Traditional energy. Renewable energy. Alternative energy. Sustainable energy. Green energy. Low-carbon energy.  **Literature: [1], [2], [4].** |
| 2 | **Lecture 2-3.** Topic 1.2. Impact of energy and transport on the environment. Prospects for the development and greening of the fuel and energy complex. Use of alternative energy resources for decarbonization of the economy.  **Literature: [1], [2], [4].** |
| 3 | **Lecture 4.** Topic 1.2. Prerequisites, formation and development of the bioenergy industry in the world and in Ukraine. The concepts of energy efficiency, energy efficiency and energy conservation. Profitability of energy production and extraction  **Literature: [1], [3], [4].** |
| 4 | **Lecture 5.** Topic 1.3. Legislative framework in the field of production and use of alternative energy resources. Legal and regulatory framework in the field of bioenergy. Economic aspects of alternative energy use  **Literature: [1], [2], [3].** |
| 5 | **Lecture 6:** Topic 2.1. Use of biomass for stationary power plants. The range of raw materials. Technical characteristics of biofuels. Potential of biofuel production in Ukraine.  **Literature: [1], [5], [6].** |
| 6 | **Lecture 7.** Topic 2.2: Biogas production technologies. Raw materials for biogas production (vegetable, animal). Design of biogas plants, principle of operation. Economic and environmental aspects.  **Literature: [1], [2], [4].** |
| 7 | **Lecture 7.** Topic 2.3. Raw materials for alternative motor fuels. Non-renewable raw materials. Plant raw materials. Secondary raw materials. Polymeric raw materials. Algae raw materials  **Literature: [1], [5], [6].** |
| 8 | **Lecture 8-9.** Topic 2.3: Alternative fuels for compression ignition engines. Biodiesel fuel. Technological processes of production. Quality characteristics. Advantages and disadvantages. Environmental aspects  **Literature: [1], [5], [6].** |
| 9 | **Lecture 10-11.** Topic 2.3: Alternative fuels for spark ignition engines. Bioethanol. Technological processes of production. Quality characteristics. Advantages and disadvantages. Environmental aspects  **Literature: [1], [5], [6].** |
| 10 | **Lecture 12-14.** Topic 2.3: Alternative fuels for gas turbine engines. Technological processes of production. Quality characteristics. Advantages and disadvantages. Environmental and economic aspects.  **Literature: [1], [5], [6].** |
| 11 | **Lecture 15:** Topic 2.3. Fuels based on polymeric raw materials. Technological processes of production. Quality characteristics. Advantages and disadvantages. Environmental aspects.  **Literature: [1], [5], [6].** |
| 12 | **Lecture 16. Topic 2.3:** Technological processes for the production of motor fuels based on microalgae. Qualitative characteristics. Advantages and disadvantages. Environmental aspects.  **Literature: [1], [2], [4].** |
| 13 | **Lecture 17-18.** Topic 3.1: The use of hydrogen in vehicles. Sources of hydrogen production. The use of hydrogen in internal combustion engines. The use of fuel cells to power vehicles. The use of hydrogen in air transport  **Literature: [1], [2], [4].** |

**Practical lessons**

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| --- | --- |
| No | Tasks to be assigned for practical classes |
| **Practical lesson 1** | Energy properties of motor biofuels. Methods for determining and calculating the density of biofuels |
| **Practical lesson 2** | Flowability of motor biofuels. Determination and calculation of biofuels viscosity |
| **Practical lesson 3** | Purity of mother liquor biofuels. Methods for determining water and impurities in fuels |
| **Practical lesson 4** | Combustibility of fuel for spark ignition engines. Methods for determining the octane number of mixed alcohol-containing fuels |
| **Practical lesson 5** | Combustibility of biofuels for compression-ignition engines. Methods for determining the cetane number of biodiesel fuel |
| **Practical lesson 6** | Low-temperature properties of biological motor fuels. Methods for determining solidification, crystallization, and turbidity temperatures |
| **Practical lesson 7** | Lubricating and antiwear properties of bio-based motor fuels. Methods for determining the lubricating characteristics of fuels |
| **Practical lesson 8** | Stability of biological motor fuels: physical, chemical, biological. Methods for determining the stability of fuels to oxidation |
| **Practical lesson 9** | Environmental properties of biological motor fuels.  Modular control work |

# 6. Student's self-study

*Student’s self-study include:*

*Preparation for classroom lessons - 56 hours;*

*Preparation to module control work – 2 hours;*

*Preparation to credit – 8 hours.*

# Policy and control

# 7. Policy of the academic discipline (educational component)

At the time of each lesson, both lecture and practical, the student must have the Google meet application installed on the device from which he or she is working (in the case of distance learning), and the course "Theoretical Fundamentals and Applied Aspects of Bioenergy Technologies" on the Sikorsky platform (the access code to the course is provided at the first lesson according to the schedule). Syllabus; lecture material; assignments for each practical lesson; variants of the module test; guidelines for practical work and calculation and graphic work; variants of the final test are available on the Sikorsky platform and in the KPI Electronic Campus system.

While taking the course "Theoretical Fundamentals and Applied Aspects of Bioenergy Technologies", students are obliged to adhere to the general moral principles and rules of ethical behavior specified in the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"

The deadlines for each assignment are specified in the course "Theoretical Fundamentals and Applied Aspects of Bioenergy Technologies" on the Sikorsky platform.

All students, without exception, are obliged to comply with the requirements of the Regulations on the system of prevention of academic plagiarism at the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute".

For participating in the All-Ukrainian Olympiad (research paper competition), a student is awarded 5 (I round) or 10 (II round) points. For writing an article and publishing it, a student is awarded 10 points (a publication included in Scopus or Web of Science) or 6 points (a professional publication of Ukraine). For publishing abstracts at a scientific conference, 3 points are awarded. The total amount of incentive points cannot exceed 10 points.

# 8. Types of control and rating system for assessing learning outcomes (RSA)

**Current control:** assignments within the framework of practical classes (9 practical classes × 10 points = 90 points), MCW (conducted directly at the practical class, in the presence of the teacher, 10 points). At the end of the lesson, the test is closed and cannot be rewritten or completed at home. The test contains twenty questions and several answers to each of them, one of which is correct. Each correct answer is worth 0.5 points.

The tasks within the practical and laboratory classes are evaluated in 5 points according to the following criteria:

* "excellent" - a complete answer (at least 90% of the required information), appropriate justifications and personal opinion are provided - 10 points;
* "good" - a sufficiently complete answer (at least 75% of the required information), which is performed in accordance with the requirements for the "skills" level or contains minor inaccuracies – 9-8 points;
* "satisfactory" - an incomplete answer (at least 60% of the required information), performed in accordance with the requirements for the "stereotypical" level and containing some errors – 7-5 points;
* "unsatisfactory" - unsatisfactory answer - 0-2 points.

**Calendar control:** is conducted twice a semester as a monitoring of the current state of fulfillment of the requirements of the sila-bus. The condition for a positive first and second calendar control is to obtain at least 50% of the maximum possible rating at the time of the relevant calendar control.

**Semester control:** credit.Conditions for admission to the semester control: completed and credited practical works and MCW. Students who have fulfilled all the conditions for admission to the test and have a rating score of 60 or more points receive a grade corresponding to the rating without additional tests. The sum of the rating points received by the student during the semester is transferred to the final grade according to the table. If the sum of points is less than 60, but practical works and ICR are completed and credited, the student performs a test work. In this case, the sum of points for practical, ICR and test work is transferred to the final grade according to the table. A student who has received more than 60 points in a semester but wishes to improve his or her result may take part in the test work. In this case, the final result consists of the points obtained in the test work and the points for practical and internship work.

The test is worth 40 points. The test task of this paper consists of three theoretical questions from the list provided in the appendix to the syllabus.

Each question and task is worth 13 points (if you get 39 points for each question, 1 point is added to the grade) according to the following criteria

- "excellent" - a complete answer (at least 90% of the required information), appropriate justifications and personal opinion are provided - 13 - 11 points;

- "good" - a sufficiently complete answer (at least 75% of the required information), which is made in accordance with the requirements for the "skills" level or contains minor inaccuracies - 12 - 10 points;

- "satisfactory" - an incomplete answer (at least 60% of the required information), performed in accordance with the requirements for the "stereotypical" level and containing some errors - 9 - 7 points;

- "unsatisfactory" - unsatisfactory answer - 0 points.

Table of correspondence between rating points and grades on the university scale:

|  |  |
| --- | --- |
| Number of points | Grade |
| 100-95 | Excellent |
| 94-85 | Very good |
| 84-75 | Good |
| 74-65 | Satisfactory |
| 64-60 | Sufficient |
| Below 60 | Non-satisfactory |
| The conditions for admission are not met | Not admitted |

# 9. Additional information on the discipline (educational component)

The list of questions submitted for semester control is given in the appendix to the syllabus.

A higher education applicant has the opportunity to take an online course(s) on one or more topics provided by the work program of the discipline. An applicant can choose an online course independently or on the recommendation of a teacher. 1 hour of the course is evaluated at 0.83 points. The maximum number of hours that can be credited for the results of non-formal education is 12 hours, respectively, the maximum number of points for such results is 10 points.

**Work program of the discipline (Syllabus):**

**Developed by** associate professor, PhD, senior researcher, Anna V. Yakovlieva

**Approved by** the department of automaton of eletrotechnic and mechatronic complexes, minutes No 17 from 31.05.23р.

**Approved by** methodic council of the ES IESEM, minutes No 9 from 22.06.23 р.

**Appendix to the syllabus of the educational component**

**"Theoretical Fundamentals and Applied Aspects of Bioenergy Technologies"**

**List of tasks to be submitted for semester control**

1. Give reasons for the transition of modern society to alternative energy sources.
2. What is the energy potential of renewable energy sources?
3. Explain the essence of the concept of "balanced energy".
4. What is the peculiarity of the concept of "low carbon energy"?
5. Give the classification of energy resources according to the degree of processing.
6. What are the primary and secondary energy resources?
7. What energy resources are not renewable energy sources? Describe them.
8. What is the difference between alternative and renewable energy sources?
9. What types of renewable energy are the result of energy radiation
10. State the main advantages of using renewable energy sources.
11. Give and describe the concept of "energy conservation". What do you know forms of energy storage?
12. What are the main differences between biofuels of the first, second and third generations?
13. Give a definition of "biogas". What is its average chemical composition? Describe the principle of operation of the biogas plant.
14. What do you know types of renewable raw materials for the production of biodiesel?
15. What types of raw materials do you know for the production of bioethanol? What is their difference?
16. Formulate criteria for the selection of raw materials for the production of bioethanol?
17. Formulate the general technical requirements for aviation fuels?
18. What are the main advantages and disadvantages of using alternative aviation fuels?
19. What do you know ways to produce hydrogen?
20. Describe the main areas of use of hydrogen fuel.
21. Describe the main resources of polymeric raw materials for alternative fuels.

1. The teacher's e-mail or other contacts for feedback, it is possible to specify office hours or hours for communication in case of contact numbers. For a syllabus of a discipline taught by many teachers (for example, history, philosophy, etc.), you can specify a page on the website where contact information for the teachers for the relevant groups, faculties, institutes is provided. [↑](#footnote-ref-2)