MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
National Technical University
"Kharkiv Polytechnic Institute"

**APPROVE**
Rector of NTU "KhPI"
_____ E. I. Sokol
"____" _____ 2022

# INTERDISCIPLINARY EDUCATIONAL AND SCIENTIFIC PROGRAM

# "SUSTAINABLE AND RENEWABLE ENERGY: ELECTRICAL AND MICROELECTRONICS ENGINEERING"

# "СТАЛА ТА ВІДНОВЛЮВАНА ЕНЕРГЕТИКА: ЕЛЕКТРИЧНА ТА МІКРОЕЛЕКТРОННА ІНЖЕНЕРІЯ"

Second level of higher education

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| by specialties | 141 "Electric Power Engineering, Electrical Engineering and Electromechanics" |
| | 153 "Micro- and Nanosystem Technology" |
| fields of knowledge | 14 "Electrical Engineering" |
| | 15 "Automation and Instrumentation" |
| qualification | Master's degree in Electrical Engineering and Microelectronics |

**APPROVED**
Academic Council of NTU "KhPI"
Protocol No. 4 from
"27" May 2022

Head of the Academic Council
_____ L. L. Tovazhnyanskyi

**Kharkiv 2022**

## PREAMBLE

This interdisciplinary educational and scientific program (hereinafter also simply Educational program) corresponds to the temporary standard of higher education for specialty 141 "Electric power, electrical engineering and electromechanics", fields of knowledge 14 "Electrical Engineering" (Approved by the academic council of the National Technical University "Kharkiv Polytechnic Institute", protocol dated November 2, 2018 No. 8) and the standard of higher education for specialty 153 "Micro- and nanosystem engineering", fields of knowledge 15 "Automation and instrumentation" (Approved and put into effect by the order of the Ministry of Education and Science of Ukraine dated November 20, 2020 No. 1447).

The educational program is developed by the project group of specialties 141 "Electric power engineering, electrical engineering and electromechanics" and 153 "Micro- and nanosystem engineering" of the National Technical University "Kharkiv Polytechnic Institute" consisting of the following.

Group leader:

Kostyantyn Makhotilo, candidate of technical sciences, senior researcher.

Group members:

- Roman Zaitsev, Doctor of Technical Sciences, Associate Professor, Head of the Department of Micro- and Nanoelectronics;
- Oleksandr Lazurenko, candidate of technical sciences, associate professor, head of the Department of Electric Power Stations;
- Oleksiy Larin, doctor of technical sciences, professor, director of the Institute of Education and Science in Computer Modeling, Applied Physics and Mathematics;
- Roman Tomashevskyi, doctor of technical sciences, professor, director of the Institute of Education and Science in Power Engineering, Electronics and Electromechanics.

**PAGE OF APPROVAL OF**
**THE EDUCATIONAL AND SCIENTIFIC PROGRAM**

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|---|---|
| Level of higher education | Second (master's) |
| Fields of knowledge | 14 Electrical engineering |
| | 15 Automation and instrumentation |
| Specialty | 141 "Electric power engineering, electrical engineering and electromechanics" |
| | 153 "Micro- and nanosystem engineering" |
| Educational program | Sustainable and renewable energy: electrical and microelectronics engineering |
| Qualification | Master of electric power and microelectronics engineering |

| **APPROVED** | **RECOMMENDED** |
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| Project group | Methodical Council of NTU "KhPI" |
| Head of the group | Deputy Chairman of the Council |
| _____ K. V. Makhotilo | _____R. P. Mygushchenko |
| " " _____ 20 . | " " _____ 20 . |

**APPROVED AND ENACTED**

By order of the rector of the National Technical University "Kharkiv Polytechnic Institute" dated "_____" _____20___ No. _____.

**CONTENTS**

# 1. PROFILE OF THE EDUCATIONAL PROGRAM

"Sustainable and renewable energy: electrical and microelectronics engineering" in the specialties 141 "Electric power engineering, electrical engineering and electromechanics" and 153 "Micro- and nanosystem engineering"

| 1 – General information | |
|---|---|
| Full name of the institution of higher education and structural subdivision | National Technical University "Kharkiv Polytechnic Institute".<br>Institute of Education and Science in Power Engineering, Electronics and Electromechanics, Department of Electric Power Stations;<br>Institute of Education and Science in Computer Modeling, Applied Physics and Mathematics, Department of Micro- and Nanoelectronics. |
| Higher education degree and qualification title in the original language | Ступінь – магістр.<br>Кваліфікація – магістр електроенергетики та мікроелектроніки.<br><br>Master's degree.<br>Qualification – Master of electric power and microelectronics engineering. |
| Official title of the educational programme | Sustainable and renewable energy: electrical and microelectronics engineering |
| Diploma type and educational program scope | Master's degree, unitary,<br>120 ECTS credits, 1 year 9 months. |
| Availability of accreditation | The program will be implemented for the first time in 2022. |
| Education cycle / level of higher education | Law of Ukraine "On Higher Education" – second (master's) level, NQF – 7th level, FQ-EHEA – second cycle, QF-LLL – 7th level. |
| Prerequisites | • Bachelor's degree in the basic specialties 141 "Electric power engineering, electrical engineering and electromechanics" or 153 "Micro- and nanosystem engineering".<br>• Bachelor's degree (from related specialties, e.g., 142, 144, 145, 151, 152, etc.). In this case, an entrance test must be held, at which the entrant must demonstrate the competencies and learning outcomes defined by the standard of higher education at the "bachelor" level for the specialty 141 "Electric power engineering, electrical engineering and electromechanics" and/or 153 "Micro- and nanosystem engineering". |
| Language(s) of instruction | Ukrainian, English |
| The term of validity of the educational program | In accordance with the validity period of the accreditation certificate |
| Permalink to the educational program location | http://blogs.kpi.kharkov.ua/v2/quality/ |
| **2 – Educational programme purpose** | |

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| Training of specialists on the border of two specialties of different fields of knowledge, capable, based on fundamental knowledge and practical skills of applying the theory of electrical engineering and micro- and nanoelectronics, to research, design and implement the latest technologies of renewable energy sources, in particular photovoltaic, to ensure the sustainable development of the energy industry. | |
| **3 – Educational program characteristics** | |
| Subject area | Fields of knowledge: 14 Electrical Engineering and 15 Automation and instrumentation.<br>Specialties: 141 "Electric power engineering, electrical engineering and electromechanics" (50%) and 153 "Micro- and nanosystem engineering" (50%).<br><br>*Objects of study and activity*:<br>– processes of generation, transmission, distribution and consumption of electric energy from renewable sources; operating principles and manufacturing processes of micro- and nanosystem technology of renewable energy sources; technologies of sustainable energy.<br>– scientific institutions, project institutions and organizations of the energy sector, enterprises of electric power and electrotechnical complexes, electrotechnical companies.<br>*The goal of study*:<br>formation of the ability to solve practical problems and scientific problems of designing and operating sustainable renewable electricity systems; research current and develop new technologies of materials and devices for micro- and nanosystem equipment of renewable energy sources.<br>*Theoretical content of the subject area*:<br>fundamental principles and methods of modeling, analysis and optimization of operating modes of power systems with renewable energy sources; fundamental bases of construction and operation of micro- and nanosystem equipment of renewable energy sources.<br>*Methods, techniques and technologies*:<br>designing, modeling the operation and control of electric power facilities and systems, measuring and modeling the characteristics of materials, devices and systems of renewable energy sources using specialized equipment and computers.<br>*Tools and equipment*:<br>electrical equipment and micro- and nanosystem technology devices, control and measuring devices, computer technology, software tools for calculating parameters and modeling of electrical and microelectronic systems, development and maintenance of project documentation. |
| Orientation of the educational program | Educational and scientific program with applied orientation.<br>The program is primarily oriented towards the training of specialists with a comprehensive vision of the entire process of renewable energy conversion and supply, capable of comprehensively solving the problems of sustainable energy development. |
| The main focus of the educational program | Special education in the field of renewable energy.<br>The main focus of the program is the use of solar energy, in particular photovoltaic systems. The program covers all issues from the physics of semiconductor converters, methods of getting maximum power, accumulation of generated energy, conversion and supply of energy to the network with given parameters, ensuring interaction with the power system and strategies for maintaining the sustainable development of energy. |

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| | Key words: renewable energy, photovoltaics, photovoltaic power plant, energy storage, sustainable energy. |
| Features of the educational program | The educational program differs in that:<br>• provides competences that are at the junction of two different fields of knowledge and specialties of higher education;<br>• offers at the beginning of training two leveling educational trajectories with blocks of the optional educational components;<br>• provides an opportunity to choose the focus of an individual educational trajectory among the most urgent tasks of sustainable energy development, represented by a wide list of optional educational components of student's choice;<br>• foresees in each semester a component of the command project work of the students;<br>• involves teaching all or most of the educational components of professional training in English. |
| **4 – Eligibility of graduates for employment and further study** | |
| Eligibility for employment | Positions in electric energy scientific institutions and companies, roles in design organizations within the fields of electric power and microelectronics engineering industry.<br>Professional opportunities of graduates (according to the Classifier of professions SC 003:2010):<br>2143.2 Electrical engineer in the power sector<br>2143.2 Power engineer<br>2143.2 Design engineer (electrical engineering)<br>2143.2 Professional in the operation of power stations, power plants and networks<br>2144.2 Electronic engineer of non-conventional and renewable energy production systems<br>2149.2 Design engineer<br>2149.2 Research engineer |
| Further study | Possibility of studying under the program of the third cycle of FQ-EHEA, level 8 EQF-LLL and level 8 NQF, i.e. graduates of higher education institution as a result of the completion of this educational program have the right to continue their studies at the educational level of PhD in specialties 141 "Electric power engineering, electrical engineering and electromechanics" or 153 "Micro- and nanosystem engineering" in universities in Ukraine and abroad, and to improve their qualifications at the "master" level in the system of postgraduate advanced training. |
| **5 – Teaching and assessment** | |
| Teaching and learning | Methods: lectures, laboratory and practical classes, command project work, practice, preparation of qualification work.<br>Approaches: student-centered, problem-oriented learning, self-learning.<br>Technologies: information and communication, block-modular, project technologies, learning as research, learning in cooperation. |
| Assessment | Rating evaluation system: current and final knowledge control (surveys, control and individual tasks, testing, etc.), tests and exams (oral and written), defense of educational projects with presentation, public defense of qualification work. |
| **6 – Program competencies** | |

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| Integral competence | The ability to solve complex specialized tasks and resolve practical problems during professional activity in the field of sustainable renewable electrical energy, as well as micro- and nanosystem technology of renewable energy sources or during the educational process, which involves conducting research and implementing innovations, and is characterized by the uncertainty of conditions and requirements. |
| General competences | GC1. Ability to abstract thinking, analysis and synthesis.<br>GC2. Ability to communicate in the national language both orally and in writing.<br>GC3. Ability to communicate in a foreign language.<br>GC4. Ability to conduct research at an appropriate level.<br>GC5. Ability to search, process and analyze information from various sources.<br>GC6. Ability to generate new ideas (creativity).<br>GC7. Interpersonal skills.<br>GC8. Ability to communicate with representatives of other professional groups at different levels (with experts from other fields of knowledge / types of economic activity). |
| Professional competencies of the specialty | PC1. The ability to reasonably choose, apply current and develop new methods, techniques, and technologies for solving engineering tasks of electric power, electrical engineering and electromechanics, as well as micro- and nanosystem engineering.<br>PC2. Ability to carry out testing and diagnostics of devices and equipment, as well as processing and analysis of the obtained results.<br>PC3. The ability to apply the acquired theoretical knowledge, scientific and technical methods to solve scientific and technical problems of electric power, electrical engineering and electromechanics, as well as micro- and nanosystem engineering, to evaluate the obtained results.<br>PC4. Ability to use modern systems of scientific and technical information search and analysis, conduct patent search and research, and protect intellectual property.<br>PC5. Ability to plan, conduct and manage theoretical and experimental scientific research in the field of electric power, electrical engineering and electromechanics, as well as micro- and nanosystem engineering.<br>PC6. Ability to develop and implement scientific and/or innovative projects in the field of electric power, electrical engineering and electromechanics, as well as micro- and nanosystem engineering.<br>PC7. Ability to design and implement efficient, reliable and safe grid-connected and stand-alone power generation installations and plants using renewable energy sources, including photovoltaics.<br>PC8. The ability to plan the implementation and manage the operation of renewable energy sources to ensure the energy industry sustainable development based on smart grid technologies, distributed generation and energy storage. |
| **7 – Program learning outcomes** | |
| Program learning outcomes of the specialty (defined by the standard of higher | LO1. Formulate and solve complex engineering, production and/or scientific problems during the design, manufacture and research of electric power, electrotechnical and electromechanical complexes and systems, as well as micro- and nanosystem technology of various purposes, creation |

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| education of the specialty) | of competitive products, and implementation of results in business projects.<br>LO2. Define directions, develop and implement projects for the creation and modernization of electric power, electrotechnical and electromechanical complexes and systems, as well as the production of micro- and nanosystem equipment, taking into account technical, economical, legal, social and environmental aspects.<br>LO3. Apply specialized conceptual knowledge, including modern scientific achievements, as well as critical comprehension of modern problems in the field of electric power, electrical engineering, electromechanics, as well as micro- and nanoelectronics, to solve complex problems of professional activity.<br>LO4. Communicate freely in national and foreign languages orally and in writing to discuss professional problems and results of activities in the field of electric power, electrical engineering, electromechanics, as well as micro- and nanoelectronics, present research results and innovative projects.<br>LO5. Gather the necessary information using scientific and technical literature, databases and other sources, analyze and evaluate it.<br>LO6. Provide team members' professional development considering global experience and requirements for personnel in the field of development and operation of electric power, electrotechnical and electromechanical complexes and systems, as well as micro- and nanoelectronic systems.<br>LO7. Build and research physical, mathematical and computer models of objects and processes of electric power, electrical engineering, electromechanics, as well as micro- and nanoelectronics.<br>LO8. Coordinate the teamwork to conduct scientific research, design, development, analysis, calculation, modeling, production and testing of electric power, electrotechnical and electromechanical complexes and systems, as well as micro- and nanosystem equipment.<br>LO9. Adhere to the principles of academic integrity.<br>LO10. Follow the principles and directions of the sustainable energy development strategy, ensuring energy security and the transition to renewable energy in Ukraine, the EU and the world.<br>LO11. Understand and use legal acts, norms, rules and standards in the field of electric power industry, in particular renewable energy sources.<br>LO12. Apply existing and master new software designed for computer modeling of objects and processes in electric power, electrotechnical and electromechanical systems, as well as micro- and nanoelectronic systems. |
| Program learning outcomes (special) | LOs1.1. Determine the optimal technologies, organization schemes and equipment parameters of electric power installations and plants based on renewable energy sources, in particular photovoltaic.<br>LOs1.2. Determine optimal technologies, equipment parameters and operation control methods of energy storage systems for maneuvering and maintaining balance in power systems with renewable energy sources.<br>LOs1.3. Plan the construction and operation management of efficient electric power installations and plants based on distributed renewable generation and smart grids technologies.<br>LOs1.4. Plan the construction and operation management of reliable and safe electric power systems with a large share of renewable energy sources based on technologies of digitalization of the electric power industry.<br>LOs2.1. Choose and apply appropriate methods of designing and re- |

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| | searching the operation of micro- and nanosystem equipment for renewable energy generation systems.<br>LOs2.2. Determine the operating modes of micro- and nanosystem technology devices to ensure the maximum efficiency of renewable generation systems, in particular photovoltaic.<br>LOs2.3. Determine directions for modernization of technological aspects of production of micro- and nanosystem technology devices for renewable generation systems, in particular photovoltaic ones.<br>LOs2.4. Plan the implementation of new design solutions in the development and production of micro- and nanosystem technology devices for renewable generation systems. |
| **8 – Resource support for educational program implementation** | |
| Staff support | In accordance with the requirements of Appendix 12 to the License Terms, approved by Resolution No. 1187 of the Cabinet of Ministers of Ukraine dated December 30, 2015; in accordance with the procedure for improving the qualifications of teaching and research-pedagogical workers, approved by Resolution No. 800 of the Cabinet of Ministers of Ukraine dated August 21, 2019.<br>All scientific and pedagogical workers who provide the educational program according to their qualifications correspond to the profile and direction of the educational components they teach, have the necessary teaching experience and practical work experience.<br>Lecturers who provide educational activities in English have certificates in accordance with the All-European recommendations for language education (level B2) or qualification documents related to the use of a foreign language. |
| Material and technical support | In accordance with the technological requirements of Appendix 13 to the License Terms, approved by Resolution No. 1187 of the Cabinet of Ministers of Ukraine dated December 30, 2015.<br>Material and technical support of the university, in particular two basic departments, allows to fully ensure the educational process during the entire training cycle according to the educational program. The condition of the premises is certified by sanitary and technical passports that comply with existing regulations.<br>The university's information and computing network, the Microsoft 365 cloud educational platform and the University's Electronic Repository provide constant access to licensed software, Internet resources and electronic educational materials both in face-to-face and distance education. |
| Informational, educational and methodological support | In accordance with the technological requirements of Appendix 14 to the License Terms, approved by Resolution No. 1187 of the Cabinet of Ministers of Ukraine dated December 30, 2015.<br>Information support is provided by textbooks, educational aids, etc. and electronic resources. Educational and methodological support is implemented by accompanying educational activities with appropriate materials from each educational component of the curriculum.<br>Students have the opportunity to use the Scientific and Technical Library of NTU "KhPI" and the Electronic Repository of NTU "KhPI" (eNTU-KhPIIR). |
| **9 – Academic mobility** | |
| National credit mobility | The possibility of concluding agreements on academic mobility, on double graduation, etc. between the National Technical University "Kharkiv Polytechnic Institute" and higher educational institutions of Ukraine. |

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| International credit mobility | The possibility of concluding agreements on international academic mobility, on double graduation, etc. between the National Technical University "Kharkiv Polytechnic Institute" and higher educational institutions of partner countries. |
| Foreign applicants' education | According to the license, foreigners and/or stateless persons can study at the National Technical University "Kharkiv Polytechnic Institute" according to the educational program.<br>In order to create conditions for the international academic mobility of teaching, all educational components can be taught in English. |

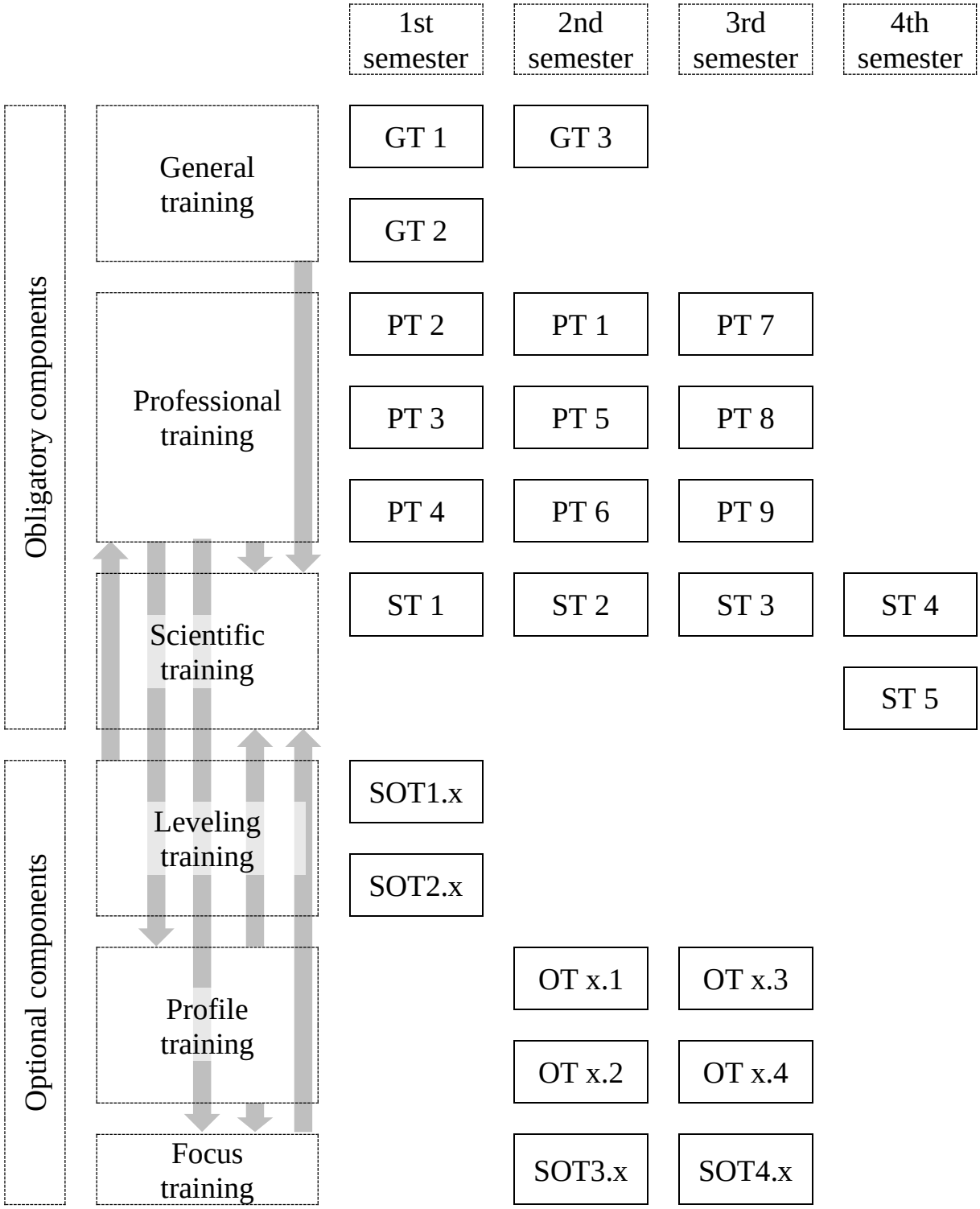
## 2. LIST OF COMPONENTS OF THE EDUCATIONAL PROGRAM AND THEIR LOGICAL CONSISTENCY

### 2.1. List of components of the educational program

| Code | Components of the educational program (educational disciplines, course projects/coursework, practice, qualification work) | Amount of credits | Final control form |
|---|---|---|---|
| **1. Obligatory educational components** | | | |
| **1.1. General training** | | | |
| GT 1 | Intellectual Property | 3 | Test |
| GT 2 | Innovative entrepreneurship and management of startup projects | 3 | Test |
| GT 3 | Language in scientific and pedagogical communication | 2 | Test |
| **1.2. Professional training** | | | |
| PT 1 | Labor and professional safety | 3 | Test |
| PT 2 | Power electronics for renewable energy systems | 5 | Exam |
| PT 3 | Physical materials science of semiconductor devices | 5 | Exam |
| PT 4 | Properties and modern research methods of semiconductor devices | 4 | Exam |
| PT 5 | Physical bases of technology for micro- and nanoelectronics | 4 | Exam |
| PT 6 | Design of renewable energy generation and energy storage systems | 5 | Exam |
| PT 7 | Relay protection&automation systems and safe operation of renewable energy plants | 4 | Exam |
| PT 8 | Design and development of renewable energy systems | 4 | Exam |
| PT 9 | Smart Grids technologies and power system digitalization | 4 | Exam |
| **1.3. Scientific training** | | | |
| ST 1 | Command project work | 2 | Test |
| ST 2 | Command project work | 2 | Test |
| ST 3 | Scientific research work | 3 | Test |
| ST 4 | Scientific research practice | 11 | Test |
| ST 5 | Attestation | 19 | Exam |
| **Total amount of the obligatory components** | | **83** | |
| **2. Optional educational components** | | | |
| **2.1. Profile training** | | | |
| **2.1.1. Profiled package 01 "Power Plant Engineering"** | | | |
| OT 1.1 | Virtual power plants | 5 | Exam |

| Code | Components of the educational program (educational disciplines, course projects/coursework, practice, qualification work) | Amount of credits | Final control form |
|---|---|---|---|
| OT 1.2 | Electricity transmission systems | 5 | Exam |
| OT 1.3 | Management of renewable energy projects | 5 | Exam |
| OT 1.4 | Computer simulation of energy storage system operating modes | 5 | Exam |
| Total | | 20 | |
| **2.1.2. Profiled package 02 "Solar Energy Engineering"** | | | |
| OT 2.1 | Semiconductor solar cells | 5 | Exam |
| OT 2.2 | Development of the modern solutions and methods of certification of solar cells | 5 | Exam |
| OT 2.3 | Combined conversion of solar energy | 5 | Exam |
| OT 2.4 | Computer modeling and design of solar energy systems | 5 | Exam |
| Total | | 20 | |
| **2.2. Leveling training** | | | |
| SOT1.x | Educational component 1 from the list of the optional student disciplines of the profile training | 5 | Exam |
| SOT2.x | Educational component 2 from the list of the optional student disciplines of the profile training | 3 | Test |
| Total | | 8 | |
| **2.3. Focus training** | | | |
| SOT3.x | Educational component 3 from the list of the optional student disciplines of the profile training | 4 | Exam |
| SOT4.x | Educational component 4 from the list of the optional student disciplines of the profile training | 5 | Exam / Test |
| Total | | 9 | |
| **Total amount of the optional components** | | **37** | |
| **Total amount of the educational program** | | **120** | |

## 2.2. Structural-logical scheme of the educational program



## 3. FORM OF ATTESTATION OF APPLICANTS OF HIGHER EDUCATION

Attestation of graduates of the interdisciplinary educational program in specialties 141 "Electric power engineering, electrical engineering and electromechanics" and 153 "Micro- and nanosystem engineering" is carried out in the form of the defense of a qualification work (master's diploma thesis) and ends with the issuance of a document of the established model on awarding a master's degree with the qualification: "Master of electric power and microelectronics engineering". Attestation is carried out openly and publicly.

The qualification work should represent the solution of a complex specialized task or practical problem in the field of electric power and microelectronics, which involves conducting research and/or implementing innovations in the technology of renewable energy sources, in particular photovoltaic, to ensure the sustainable development of the energy industry.

The qualification work must be checked for plagiarism using software and technical tools, and must also be placed in the repository of the higher educational institution or the relevant structural unit.

## 4. MATRIX OF CORRESPONDENCE OF PROGRAM COMPETENCIES TO THE COMPONENTS OF THE EDUCATIONAL PROGRAM

| | GT 1 | GT 2 | GT 3 | PT 1 | PT 2 | PT 3 | PT 4 | PT 5 | PT 6 | PT 7 | PT 8 | PT 9 | ST 1 | ST 2 | ST 3 | ST 4 | ST 5 | OT 1.1 | OT 1.2 | OT 1.3 | OT 1.4 | OT 2.1 | OT 2.2 | OT 2.3 | OT 2.4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GC1** | ● | ● | | | | | | | | | | | | | | | | | | | | | | | |
| **GC2** | ● | ● | | | | | | | | | | | | | | | | | | | | | | | |
| **GC3** | ● | | ● | | | | | | | | | | | | | | | | | | | | | | |
| **GC4** | ● | ● | ● | | | | | | | | | | ● | ● | ● | ● | ● | | | | | | | | |
| **GC5** | ● | | | | | | | | | | | | ● | ● | ● | ● | ● | | | | | | | | |
| **GC6** | ● | ● | | | | | | | | | | | ● | ● | ● | ● | ● | | | | | | | | |
| **GC7** | | ● | | | | | | | | | | | ● | ● | | | | | | | | | | | |
| **GC8** | ● | ● | | | | | | | | | | | | | ● | ● | | | | | | | | | |
| **PC1** | | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● | | ● | ● | ● | ● | ● |
| **PC2** | | | | | ● | ● | ● | | | ● | | | | | | | | | | | ● | ● | ● | | ● |
| **PC3** | | | | | | | ● | ● | ● | | ● | ● | ● | ● | ● | | ● | ● | ● | | ● | ● | | ● | ● |
| **PC4** | | ● | | | | | | | | | | | | | ● | | ● | ● | | ● | | | | | |
| **PC5** | | ● | | | | | ● | ● | | | | | ● | ● | ● | ● | ● | | | ● | ● | | ● | | ● |
| **PC6** | | ● | | | | | ● | | ● | | ● | ● | ● | ● | ● | | ● | | | ● | | | | ● | |
| **PC7** | | | | ● | ● | ● | | | ● | ● | ● | ● | | | | | ● | ● | ● | ● | ● | ● | | ● | ● |
| **PC8** | | | | | | | | | ● | ● | ● | ● | | | | | ● | ● | ● | ● | ● | | | ● | ● |

## 5. MATRIX FOR PROVIDING PROGRAM LEARNING OUTCOMES WITH THE RELEVANT COMPONENTS OF THE EDUCATIONAL PROGRAM

| | GT 1 | GT 2 | GT 3 | PT 1 | PT 2 | PT 3 | PT 4 | PT 5 | PT 6 | PT 7 | PT 8 | PT 9 | ST 1 | ST 2 | ST 3 | ST 4 | ST 5 | OT 1.1 | OT 1.2 | OT 1.3 | OT 1.4 | OT 2.1 | OT 2.2 | OT 2.3 | OT 2.4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LO1** | ● | ● | | | ● | | | | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● | |
| **LO2** | | ● | | ● | | | | | ● | ● | ● | ● | ● | ● | ● | | ● | ● | | ● | | | ● | | ● |
| **LO3** | ● | | | | ● | | ● | | ● | | ● | ● | ● | ● | ● | | ● | ● | | ● | | | ● | ● | |
| **LO4** | ● | ● | ● | | | | | | | | | | ● | ● | ● | ● | ● | | | | | | | | |
| **LO5** | ● | | | | | | | | | | | | ● | ● | ● | ● | ● | | | | | | | | |
| **LO6** | ● | ● | | ● | | | | | | | | | ● | ● | ● | | | | | | | | | | |
| **LO7** | | ● | | | ● | ● | ● | ● | | | | ● | | | | | | ● | | | ● | ● | ● | | ● |
| **LO8** | | ● | | ● | | | | | ● | | ● | | ● | ● | ● | ● | ● | | | ● | | | | | |
| **LO9** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **LO10** | | | | | | | | | ● | | ● | ● | ● | ● | ● | | ● | ● | | ● | | | | ● | |
| **LO11** | ● | ● | | ● | | | | | ● | ● | ● | | | | | | | | ● | ● | | | ● | | |
| **LO12** | ● | ● | | | | | | | | | | | ● | ● | ● | | ● | | | | | | | | |
| **LOs1.1** | | | | | | | | | ● | ● | ● | ● | | | | | | | ● | | ● | | | ● | ● |
| **LOs1.2** | | | | | | | | | ● | ● | | ● | | | | | | ● | | | ● | | | | ● |
| **LOs1.3** | | | | | | | | | | | | ● | | | | | | ● | | | | | | | |
| **LOs1.4** | | | | | | | | | | ● | | ● | | | | | | | | | | | | | |
| **LOs2.1** | | | | | | | ● | ● | | | | | | | | | | | | | | ● | | | |
| **LOs2.2** | | | | | | | | | | | | | | | | | | | | | | | ● | | ● |
| **LOs2.3** | | | | | | | | ● | | | | | | | | | | | | | | ● | ● | | |
| **LOs2.4** | | | | | | | ● | | | | | | | | | | | | | | | | | ● | ● |