

MINISTRY OF SCIENCE AND HIGHER EDUCATION OF THE RUSSIAN FEDERATION
Federal State Autonomous Educational Institution for Higher Education
«North-Caucasus Federal University»

APPROVED BY

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ASSESSMENT TOOLS FOR THE DISCIPLINE (MODULE)
«Optimization Methods in Power Systems»

Field of study	<u>13.04.02 Electric Power Engineering and Electrical Engineering</u>
Specialization (Profile)	<u>Training Program of Electrical Engineering</u>
Year of commencement of studies	<u>2026</u>
Mode of study	<u>full-time</u>
Implemented in semester(s)	<u>1</u>

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Foreword

1. Purpose: This assessment tools (AT) document is intended to assess the level of competency formation during ongoing progress control and intermediate assessment of students in the discipline "Optimization Methods in Power Systems".

2. The AT is an appendix to the syllabus of the discipline "Philosophy".

3. Developer: Evgenii G. Zelenskii, Candidate of Technical Sciences, Associate Professor.

4. The AT has undergone expert review. Members

of the expert group:

Chairperson: Yu. G. Kononov, Doctor of Technical Sciences, Professor, Head of the Department of Automated Electric Power Systems and Power Supply.

Committee members:

D.A. Kostyukov, Candidate of Technical Sciences, Associate Professor, Department of Automated Electric Power Systems and Power Supply.

A.V. Petrov, Candidate of Technical Sciences, Associate Professor, Department of Automated Electric Power Systems and Power Supply.

Representative of the employer organization:

S.A. Filippov, Candidate of Technical Sciences, Head of the Leninsky District Department of the Stavropol Interdistrict Branch of the PJSC «Stavropolenergosbyt».

Expert opinion: The AT is recommended for assessing the level of competency formation during ongoing progress control and intermediate assessment of students in the discipline "Optimization Methods in Power Systems".

5. The validity period of the AT is determined by the period of implementation of the educational program.

1. Description of indicators and criteria for assessment at various stages of their formation, description of grading scales

Competency(ies), indicator(s)	Levels of competency formation			
	Minimum level not achieved (Unsatisfactory) – 2 points	Minimum level (Satisfactory) – 3 points	Medium level (Good) – 4 points	High level (Excellent) – 5 points
UC-1 Capable of conducting critical analysis of problem situations based on a systems approach and developing an action strategy				
Indicator: ID-2 UC-1. Analyses a problem situation and performs its decomposition into individual tasks	The student is not able to independently formalize an engineering problem. They can only reproduce (with errors or from a template) a mathematical model for a very simple, typical task, if all its components (objective function, variables, constraints) are already defined.	The student is able to formalize a typical optimization task (e.g., loss reduction in a simple network), defining its main components: the objective function, control variables, and a system of constraints.	The student is able to formalize a complex, non-standard engineering problem from the electric power industry as a mathematical optimization model, correctly defining all its elements and their interconnections.	The student is able not only to formalize the problem but also to critically evaluate the correctness of its formulation, identify hidden assumptions, and propose ways to refine it or decompose it into subtasks for more efficient solving.
Indicator: ID-3 UC-1. Develops a strategy for solving the assigned task	The student is not able to develop a solution strategy. They can only apply one method they know to a task without considering its adequacy, or execute algorithm steps by following instructions.	The student is able to select and justify the most effective numerical method for solving the assigned task from a proposed list, understanding the basic conditions for its applicability.	The student is able to independently develop a solution strategy by analyzing the nature of the task and select the optimal method (e.g., between deterministic and stochastic), justifying their choice with its advantages and disadvantages in the given context.	The student is able to synthesize a hybrid solution strategy, combining elements of different methods to achieve the best result in complex tasks with conflicting requirements.
PC-1 Capable of participating in research and development activities in the field of electrical power engineering				
Indicator: ID-1 PC-1. Performs analysis and processing of scientific and technical information on the research subject from domestic and foreign sources;	The student is not able to analyze and systematize information. They can find and retell the definition of one method from a textbook but are not able to compare it with others or evaluate its applicability.	The student is able to conduct a comparative analysis of two or three methods based on given criteria (e.g., accuracy vs. speed) for standard operating conditions of a power system.	The student is able to independently generalize information from various sources about the applicability of a wide range of approaches (linear, non-linear, heuristic) for analyzing specific, including non-standard, power system operating conditions.	The student is able to conduct an in-depth meta-analysis of existing research, identify gaps in applied methods, and formulate new directions for research activities based on this.
Indicator: ID-2 PC-1. Conducts experiments according to a given methodology; processing and analyses research results;	The student is not able to implement models in code and conduct experiments. They can run a ready-made script and read the output, but do not understand its essence and cannot change parameters.	The student is able to implement a mathematical model and algorithm as program code (e.g., in Python) and conduct a computational experiment following a standard methodology. They can process basic results (e.g., plot a graph).	The student is able to independently plan and conduct a series of computational experiments to study algorithm convergence and analyze the solution's sensitivity to changes in input parameters.	The student is able to develop new methodologies for conducting experiments for verification and validation of complex models, as well as interpret non-trivial results to obtain new scientific conclusions.
PC-2 Capable of participating in the design of objects of professional activity				

Indicator: ID-1 PC-2. Performs calculation and analysis of the economic and technical characteristics of the object being designed;	The student is not able to solve complex tasks. They can perform a simple calculation using a single formula (e.g., payback period) but cannot integrate it into a problem with multiple techno-economic constraints.	The student is able to formulate and solve typical techno-economic optimization problems with a limited number of variables (e.g., choosing the optimal operating mode for a simple facility).	The student is able to formulate and solve complex techno-economic optimization problems with many variables and constraints, evaluating capital (CAPEX) and operational (OPEX) expenditures to select the best option.	The student is able to create comprehensive models for analyzing the life cycle of power industry facilities, taking into account long-term economic forecasts, risks, and external factors.
Indicator: ID-2 PC-2. Evaluates the feasibility of implementing an investment project and selects the most optimal investment alternative.	The student is not able to compare alternatives. They can describe one project or calculate one indicator of its effectiveness, but cannot conduct a comparative analysis.	The student is able to build a multi-criteria model for comparing 2-3 simple investment alternatives based on basic economic indicators.	The student is able to build complex multi-criteria models for comparing various investment alternatives in the electric power industry, evaluating their economic efficiency and risks while taking into account technical constraints.	The student is able to comprehensively assess the investment attractiveness of large-scale power system modernization projects using advanced decision support and risk management methods.

ASSESSMENT TOOLS FOR CHECKING THE LEVEL OF COMPETENCY FORMATION

Task No.	Correct Answer	Question Content	Competency
1.	b)	What is the main goal of applying optimization methods in modern electric power systems? a) Increasing the installed capacity of generators b) Reducing electricity losses and improving economic efficiency c) Replacing all equipment with new ones d) Increasing the frequency of alternating current	UC-1
2.	c)	Which method is used to solve large-scale linear programming problems when the graphical method is not applicable? a) Newton's method b) Method of indeterminate Lagrange multipliers c) Simplex method d) Coordinate descent method	UC-1
3.	b)	The optimal distribution of active power among thermal power plants in a power system is a classic problem of... a) Linear programming b) Non-linear programming c) Dynamic programming d) Integer programming	UC-1
4.	b)	What is the main purpose of creating a digital (mathematical) model of an electric network? a) Visualization of a substation scheme b) Power flow calculation and optimization to reduce energy losses c) Determining the color of power line wires d) Calculating construction costs	UC-1
5.	c)	Which organizational measure for network optimization involves changing the configuration of connections between nodes? a) Load balancing b) Transformer tap position optimization c) Topology reconfiguration d) Replacing conductor cross-section	UC-1
6.	b)	What is the main idea of the coordinate descent method? a) Random search for a solution in the entire space b) Searching for a solution by changing one variable at a step while fixing the others c) Using higher-order derivatives d) Modeling biological evolution	UC-1

7.	c)	What is the essence of the Monte Carlo method when solving optimization problems? a) Using deterministic calculations to find the minimum b) Applying linear algebra methods to stochastic processes c) Using random sampling to explore the solution space d) Solving a system of differential equations	UC-1
8.	b)	What biological process underlies the operation of genetic algorithms? a) Photosynthesis b) Natural selection and crossover (recombination) c) Cell division (mitosis) d) Metabolism	UC-1
9.	b)	What type of measure does replacing wires with conductors of a larger cross-section or replacing transformers belong to? a) Organizational measures b) Technical measures c) Economic measures d) Administrative measures	UC-1
10.	b)	What constraint is necessarily taken into account when developing a program to reduce electricity losses using linear programming? a) Wind speed limitation b) Financial (budgetary) constraints on network modernization c) Voltage phase angle limitation d) Color scheme limitation of equipment	UC-1
11.		Define the objective function in an optimization problem for an electric power system.	PC-1
12.		Describe the graphical method for solving a linear programming problem and name its main limitation.	PC-1
13.		What are indeterminate Lagrange multipliers used for in non-linear optimization problems?	PC-1
14.		What role do telemetry data (telesignals) play when building a mathematical network model in Python?	PC-1
15.		Name two main differences between heuristic optimization methods (e.g., genetic algorithm or ant colony method) and classical mathematical methods.	PC-1
16.		Explain how financial constraints affect the formation of an optimal plan for electric network modernization.	PC-1
17.		Formulate the state estimation problem as an optimization problem.	PC-1
18.		What is a PMU (Phasor Measurement Unit) and what is the goal of the optimal placement problem?	PC-1
19.		What is the principle of operation of the simulated annealing method and what physical analogy is used to describe it?	PC-1
20.		List three main components of any optimization problem.	PC-1
21.	A-3, B-4, C-1, D-2	Match the optimization method with its key characteristic. A. Simplex method 1. Imitates the process of biological evolution. B. Steepest descent method	PC-2

		2. Solves the problem by changing one variable at a time. C. Genetic algorithm 3. A classic algorithm for linear programming problems. D. Coordinate descent method 4. Movement in the direction of the antigradient to find a function's minimum.	
22.	A-3, B-1, C-2, D-4	Match the optimization task in power systems with its goal. A. Topology reconfiguration 1. Minimizing the weighted sum of squared deviations between measured and calculated data. B. State Estimation 2. Ensuring full network observability with a minimum number of devices. C. PMU placement optimization 3. Reducing power losses by changing the network connection scheme. D. Loss reduction program optimization 4. Developing a cost-effective modernization plan considering the budget.	PC-2
23.	A-2, B-1, C-3, D-4	Match the method with its main idea or analogy. A. Monte Carlo method 1. Searching for a solution based on modeling the behavior of an ant colony looking for the shortest path to food. B. Ant colony optimization 2. Using random sampling to obtain numerical results and find a solution. C. Simulated annealing 3. Modeling the process of controlled metal cooling to get rid of "stresses" (local minima). D. Linear programming 4. Finding the extremum of a linear function subject to a system of linear constraints on variables.	PC-2
24.	A-2, B-4, C-1, D-3	Match the optimization method with its key feature or application area. A. Simplex method 1. Is most effective for problems where the search space can be represented as a graph or network of paths. B. Genetic algorithm 2. Is the classic and most effective for solving linear programming problems. C. Ant colony optimization 3. Is based on probabilistic decision-making, which allows it to "escape" from local minima. D. Simulated annealing 4. Uses mechanisms of natural selection and is well-suited for problems with a large number of local optima.	PC-2
25.	A-2, B-1, C-3, D-4	Match the method with the type of problem it is most effective for or is characteristic of. A. Method of Lagrange multipliers 1. Problems with discrete variables and a complex objective function (combinatorial problems). B. Genetic algorithm 2. Nonlinear programming problems with equality constraints (NLPs). C. Simplex method	PC-2

		3. Classic linear programming problems (LPs). D. Ant colony optimization 4. Combinatorial optimization problems, e.g., finding the shortest path or TSP (Traveling Salesman Problem).	
26.	A-1, B-2, C-3, D-4	Match the organizational measure with its technical essence or result. A. Load balancing across phases 1. Redistributing loads between phases to reduce current in the neutral wire and corona losses. B. Transformer tap position optimization 2. Changing the transformation ratio to maintain consumer voltage and reduce losses. C. Network topology reconfiguration 3. Opening/closing current division points to redirect power flows and reduce total losses. D. Searching for closed loops in a network 4. An algorithmic task necessary for performing topology reconfiguration without breaking network connectivity.	PC-2
27.	A-1, B-2, C-3, D-4	Match the technical measure with its impact on network parameters or project economics. A. Replacing conductor cross-sections 1. Reducing active losses by decreasing the resistance of the power line (TL). B. Replacing transformers 2. Reducing both load and no-load losses in transformer equipment. C. Accounting for financial constraints (LP) 3. Forming an optimal modernization plan that does not exceed the allocated budget (CAPEX/OPEX). D. Power flow calculation in Python 4. Quantitative assessment of the effect of implementing technical measures before their physical implementation.	PC-2
28.	A-1, B-2, C-3, D-4	Match the component/method with its role in the State Estimation task. A. Telemetry data (Telesignals) 1. Input information (measurements) on which the real-time network state assessment is built. B. Mathematical network model 2. A tool for calculating power flow and computing residuals between measured and calculated data. C. Minimization criterion (weighted sum of squares) 3. The mathematical function that must be minimized to obtain the most probable state vector of the network. D. State vector (State Vector) 4. The output result of the task — a set of the most probable values of mode parameters (voltages, phases) at all network nodes.	PC-2
29.	A-1, B-2, C-3, D-4	Match the optimization method with its main advantage or disadvantage. A. Steepest descent method 1. Simple to implement, but can get "stuck" in a local minimum on complex surfaces. B. Genetic algorithm 2. High probability of finding a global optimum due to "population" diversity, but requires high computational	PC-2

		resources (CPU). C. Simulated annealing 3. Ability to "escape" from local minima by probabilistically accepting worse solutions at the initial stage ("high temperature"). D. Monte Carlo method 4. Versatility and ability to estimate outcome probabilities, but slow convergence to an exact solution.	
30.	A-1, B-3, C-2, D-4	Match the power system optimization task with its main goal. A. Optimal active power dispatch (economic dispatch) 1. Minimize the total fuel cost while covering the system load. B. Network topology reconfiguration 2. Find such a placement of measurement devices to monitor the entire network with their minimum number. C. PMU placement optimization 3. Reduce technical power losses by changing the configuration of network connections. D. Loss reduction program development with budget constraints 4. Find a compromise between the desired effect of modernization and the available financial resources.	PC-2

2. Description of the grading scale

Within the framework of the rating system, student performance in each discipline is assessed during ongoing progress control and intermediate assessment. The rating system for assessing student knowledge is based on the use of a set of control measures (checkpoints) for testing the material covered, optimally located throughout the entire time interval of studying the discipline. The principles of the rating system for assessing student knowledge are based on the provisions described in the "Regulations on the organization of the educational process based on the rating system for assessing student knowledge" at North Caucasus Federal University.

The rating assessment system is not provided for students studying in master's degree programs, or for students studying in bachelor's degree programs by correspondence or part-time (evening) forms of study.

3. Criteria for assessing competencies

The grade "Excellent" is awarded to a student who has deeply and firmly mastered the program material, presents it exhaustively, consistently, clearly, and logically coherently, is able to closely link theory with practice, handles tasks, questions, and other types of knowledge application with ease, and does not struggle to answer when assignments are modified.

The grade "Good" is awarded to a student who has a solid command of the material, presents it competently and substantively without making significant inaccuracies in answering questions, correctly applies theoretical principles to practical questions and tasks, and possesses the necessary skills and techniques for their execution.

The grade "Satisfactory" is awarded to a student who has knowledge of only the basic material but has not mastered its details, makes inaccuracies, insufficiently correct formulations, and violates logical sequence in presenting the program material.

The grade "Unsatisfactory" is awarded to a student who does not know a significant part of the program material and makes substantial errors.