**Syllabus**
Course Program

# Modern Combined Cycle Power Plants

**Specialty**
G4 – Engineering, Manufacturing and Construction

**Specialization**
G4.03 Renewable Energy Sources and Hydropower
*(if applicable)*

**Educational program**
Hydropower Engineering

**Level of education**
Second (master's level)

**Semester**
1

**Institute**
Institute of mechanical engineering and transport

**Department**
Department of Energy machinery engineering named after G.F. Proskura (150)

**Course type**
Educational components of free choice of professional training

**Form of study**
Full-time learning

**Language of instruction**
English

## Lecturers and course developers

**Oksana Lytvynenko**

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Candidate of Technical Sciences (PhD), Associate Professor, Professor at the Department of Energy machinery engineering named after G.F. Proskura, NTU "KhPI"

Over 20 years of professional experience. Author of more than 50 scientific and educational-methodological publications.

Lead lecturer in the following courses: "Theory and Computer-Aided Design of Gas Turbine Plant Schemes," "Heat and Mass Transfer Processes, Equipment and Installations," "Heat and Mass Transfer Installations in Industry," "Innovative Problems, Technical Standards and Non-Technical Aspects of Power Engineering," "Modern Combined Energy Systems," and others.
More about the lecturer on the department's website

## General information

### Summary

Within the course "Modern Combined Cycle Power Plants," students will gain knowledge of the main configurations of energy systems, including combined-cycle steam- gas power plants, their design features, and the fundamental principles of their analysis and design calculations.

### Course objectives and goals

To develop students' knowledge and skills in the key processes of combined-cycle power plants, current trends in their development, and methods for their analysis and design calculations.

### Format of classes

Lectures, practical classes, consultations self-study. Final control in the form of an differentiated grading.

### Competencies

Ability to understand the principles of operation and main configurations of combined-cycle power plants.
Ability to analyze thermodynamic processes and assess the efficiency of power plants.
Ability to perform basic calculations of parameters and performance indicators of combined-cycle power plants.
Ability to evaluate modern technologies and development trends in combined-cycle power generation.

### Learning outcomes

Describe the main types, configurations, and operating principles of combined-cycle power plants;
Explain their design features and thermodynamic processes;
Analyze the energy and economic efficiency of power plants;
Perform basic calculations and justify the selection of key parameters;
Identify current trends in the development of combined-cycle power generation technologies.

### Student workload

The total volume of the course is 120 hours (4 ECTS credits): lectures – 32 hours, practical classes – 16 hours, self-study – 72 hours.

### Course prerequisites

Basic knowledge of thermodynamics, heat transfer, fluid mechanics, and turbomachinery.

### Features of the course, teaching and learning methods, and technologies

The course material is delivered through lectures using multimedia technologies (thematic videos and presentations), practical classes (problem-solving), and a calculation assignment

## Program of the course

### Academic classes

#### Lectures

| Topics of the lectures | Hours |
|---|---|
| **Topic 1. Introduction. History of Combined-Cycle Power Plants. Types of CCPPs. Configurations** | 2 |
| **Topic 2. CCPPs with Regeneration Replacement and with Low-Pressure and High-Pressure Steam Generators** | 4 |
| **Topic 3. Selection of a Gas Turbine Unit for a Given Steam Turbine Unit. Calculation Features of CCPPlants with High-Pressure and Low-Pressure Steam Generators** | 2 |
| **Topic 4. Thermal Schemes and Performance Indicators of CCP Plants with Heat Recovery Steam Generators (HRSGs). Single-Pressure and Dual-Pressure HRSG Configurations** | 2 |
| **Topic 5. Main Types of Boiler Plants. Operating Principle of a Natural-Circulation Boiler. Types of Fuels and Auxiliary Equipment** | 2 |

| | |
|---|---|
| **Topic 6. Mass Balance of Working Fluids in a Boiler. Heat Balance of a Boiler Plant. Energy Sources for Boiler Plants** | 2 |
| **Topic 7. Classification, General Characteristics of Combustion Processes. Combustion Arrangements for Different Types of Fuels** | 2 |
| **Topic 8. Combustion Chambers of Gas Turbine Plants. Design Features. Fuel Characteristics. Calculation of Combustion Processes** | 2 |
| **Topic 9. Combustion of Gaseous, Liquid, and Solid Fuels** | 2 |
| **Topic 10. Schemes and Methods for Utilizing Exhaust Gas Heat in Gas Turbine Cycles** | 2 |
| **Topic 11. Gas Turbine Plants with Working-Fluid Mixing. STIG and A-STIG Systems. Configurations and T–S Diagrams** | 2 |
| **Topic 12. Contact-Type Systems. Thermodynamic Properties of Gas–Steam Mixtures. Specific Features of the Thermodynamic and Gas-Dynamic Analysis of STIG Systems** | 2 |
| **Topic 13. Gas Turbine Plants with Water Injection into the Compressor Flow Path** | 2 |
| **Final Class. Questions and Answers** | 2 |
| **Total hours** | **32** |

## Practical classes

*If applicable*

| Topics for practical classes | Hours | Weighting coefficients *a* |
|---|---|---|
| **Topic 1. Problem Solving: "Calculation of the Power Output and Efficiency of Steam Turbine (ST) and Gas Turbine (GT) Power Plants"** | 4 | 1 |
| **Topic 2. Problem Solving: "Calculation of a Combined-Cycle Power Plant with Separate Working-Fluid Circuits"** | 4 | 1 |
| **Topic 3. Problem Solving: "Mass and Heat Balance of a Boiler Plant"** | 2 | 1 |
| **Topic 4. Problem Solving: "Calculation of a Three-Shaft Gas Turbine Plant Operating on Combustion Products"** | 2 | 1 |
| **Topic 5. Problem Solving: "Calculation of a Three-Shaft Gas Turbine Plant Operating on a Gas–Steam Mixture"** | 4 | 1 |
| **Total hours** | **16** | $\sum_{i=1}^{n} a_i = 5$ |

## Control works

*If applicable*

| Topics for control works (testing) | Weighting coefficients *b* |
|---|---|
| **Topic 1. Combined-Cycle Power Plants with Separate Working-Fluid Circuit** | 1 |
| **Topic 2. Boiler Plants** | 1 |
| **Topic 3. Gas–Steam Power Plants. Contact-Type Systems** | 1 |
| **Total** | $\sum_{i=1}^{m} b_i$=3 |

### Self-study

Self-study includes independent work on theoretical materials and completion of individual assignments

#### Work on theoretical materials

| Topics for self-study | Hours |
|---|---|
| **Review of lecture materials and preparation for practical classes.** | 52 |
| **Completion of the calculation assignment.** | 20 |
| **Total hours** | **72** |

#### Topics for individual assignments

Calculation assignment: "Calculation of a Gas–Steam Power Plant with a Heat Recovery Steam Generator (HRSG)".

## Non-formal education

(if available).

**Recommended training courses, internships**

## Literature, training materials, and information resources

### Main literature

1. Lytvynenko, O.O. Lecture Notes for the Course "Modern Combined Energy Systems". NTU "KhPI", 2026. (Electronic version)
2. Boyce, M., Gonzalez, F. — Combined Cycle Power Plants: Emphasis on Gas and Steam Turbine Operations. Texas A&M Engineering Experiment Station, 2015. PDF, 304 KB. https://hdl.handle.net/1969.1/162162
3. Abdulkareem, M. A. — Power Plant Lecture Notes, Chapter 6: Gas Turbines & Combined Cycles. https://www.researchgate.net/publication/304396458_Power_Plant_Lecture_Notes_-_CHAPTER-6_Gas_Turbines_Combined_Cycles
4. Erlich, C. — HRSG Fundamentals KTH, 2005/2006. https://pdfcoffee.com/hrsg-fundamentals-pdf-free.html?utm_source=chatgpt.com

## Grading system

The final grade for the educational component is determined by the lecturer and is based on topics, types of activities, etc., in accordance with the syllabus. It is an integrated assessment of the results of all types of student learning activities. The final grade should reflect all the grades for the different parts of the educational process, taking into account their weighting coefficients $k$:

| Continuous assessment (during practical classes) $k_1$ | Control works (if any), $k_2$ | Individual assignment (if any), $k_3$ | Final assessment (for courses with exams), $k_4$ |
|---|---|---|---|
| 0,3 | 0,5 | 0,2 | 0 |

The sum of the coefficients must be equal to one: $k_1 + k_2 + k_3 + k_4 = 1$. The weighting coefficients for the final assessment are decided by the course developer..
The final grade is calculated using the following formula:

$$G = C \cdot k_1 + K \cdot k_2 + I \cdot k_3 + E \cdot k_4$$

where: $C$ – weighted average score for the continuous assessment
$I$ – individual assignment grade
$K$ – weighted average score for the continuous assessment
$E$ – final assessment (exam) grade

$$C = \frac{C_1 \cdot a_1 + C_2 \cdot a_2 + \ldots + C_n \cdot a_n}{\sum_{i=1}^{n} a_i}$$

де: $a_i$ - weighting coefficient for each workshop (seminar) or laboratory class.

$$K = \frac{K_1 \cdot b_1 + K_2 \cdot b_2 + \ldots + K_m \cdot b_m}{\sum_{i=1}^{m} b_i}$$

де: $b_i$ - weighting coefficient for each control work.

The assessments for each component (C, K, I, etc.) are based on a 100-point scale in line with the provisions of the "Criteria and System for Assessing Knowledge and Skills, and Rating of Higher Education Students" of the National Technical University "Kharkiv Polytechnic Institute."

The final grade is finalized as the calculated value of *G*, rounded up to the nearest integer.

**Grading scale**

| Total points | National | ECTS |
|---|---|---|
| 90–100 | Excellent | A |
| 82–89 | Good | B |
| 75–81 | Good | C |
| 64–74 | Satisfactory | D |
| 60–63 | Satisfactory | E |
| 35–59 | Unsatisfactory (requires additional learning) | FX |
| 1–34 | Unsatisfactory (requires repetition of the course) | F |

## Norms of academic integrity and course policy

Students must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to demonstrate discipline, good manners, kindness, honesty, and responsibility. Conflict situations should be openly discussed in academic groups with a lecturer, and if it is impossible to resolve the conflict, they should be brought to the attention of the Institute's management.
Regulatory and legal documents related to the implementation of the principles of academic integrity at NTU "KhPI" are available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

## Approval

Approved by 27.08.2026 **Head of the department**
Andrii ROGOVYI

27.08.2026 **Guarantor of the educational program**
Andrii ROGOVYI