Syllabus
Course Program

Ecological Aspects of Power Industry

Specialty
141 – Electric Power Engineering, Electrical Engineering and Electromechanics

Institute
Institute of Education and Science in Power Engineering, Electronics and Electromechanics

Educational program
Electrical Power Engineering

Department
Electric Power Stations (130)

Level of education
Master's level

Course type
Special (professional), Optional

Semester
2

Language of instruction
English, Ukrainian

Lecturers and course developers

Liudmyla Lysenko

Liudmyla.Lysenko@khpi.edu.ua
Candidate of Technical Sciences, Associate Professor, Associate Professor at the Department of Electric Power Stations

Lecturing experience of 18 years. Author and co-author of over 60 scientific and educational works. The courses delivered: Automatic Control Theory in Problems of Electricity and Energy Efficiency, Mathematical Tasks of Power Engineering, Optimization Problems of Power Engineering, Ecological Aspects of Power Industry.
More about the lecturer on the department's website

General information

Summary

The course of Ecological Aspects of Power Industry familiarize students with adopted international and national programs aimed at mitigating climate change resulted from anthropogenic emissions increase in order to promote sustainable development, gives knowledge of power industry contribution to adverse effects of climate change, trains practical skills in numerically assessing ecological effect of conventional and non-conventional power plants operation, and develops the ability to analyze and take into consideration environmental consequences of power facilities operation.

Course objectives and goals

Goal:
Acquiring understanding of sustainable development goals and measures undertaken for their realization; gaining knowledge of environmental impact of power industry and techniques of estimating ecological harm done by fossil fuel burning and benefits of state-of-the art energy-efficient technologies allowing ecological electricity production.
Objectives:
To know:
– international and national programs and strategies of promoting sustainable development;
– technological, fuel, and operational causes of power industry action on the environment;
– available techniques and technologies of reducing harmful effect of power industry;

– state-of-the-art resource-saving technologies of electricity production.

To be able to:
– conduct numerical assessment of harmful emissions by fossil fuel fired power plants and estimate buffer zone area for such plants;
– make out measures and practical recommendations aimed at environment protection in power industry on the base of available international and national eco-friendly practices;
– assess environmental and economic benefits of implementing resource-saving and renewable energy technologies in power industry.

Format of classes

Lectures, workshops, consultations, self-study, individual assignments, report, module tests. The final control is exam.

Competencies

General competences:
GC 1. Ability to think, analyze and synthesize.
GC 4. Ability to apply knowledge in practical situations.
Professional competences:
PC 1. Ability to apply the obtained theoretical knowledge, scientific and technical methods and corresponding software for the decision of scientific and technical problems and carry out scientific researches in the field of power engineering, electrical engineering and electromechanics.
PC 5. Ability to understand and take into account social, environmental, ethical, economic and commercial considerations that influence the implementation of technical solutions in power engineering, electrical engineering and electromechanics.
PC 8. Knowledge and understanding of modern technological processes and systems of technological preparation of production, technical characteristics, design features, purpose and rules of operation of electric power, electrical and electromechanical equipment and equipment.

Learning outcomes

PLO 2. To analyze processes in electric power, electro-technical and electromechanical equipment and corresponding complexes and systems.
PLO 21. To analyze the current state and identify trends in the development of technologies and methods of energy saving, increase energy efficiency and use of renewable energy sources, in particular market mechanisms for stimulating energy efficiency.

Student workload

The total volume of the course is 150 hours (5 ECTS credits):
For full-time students:
lectures - 32 hours, workshops - 32 hours, self-study - 86 hours.
For correspondence students:
lectures - 8 hours, workshops - 4 hours, self-study - 138 hours.

Course prerequisites

For successful completion of the course, knowledge and skills acquired in such disciplines as Physics, Chemistry, Ecology, Electrical Systems and Networks, Renewable Energy Sources and Power Facilities will help.

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

Lectures are conducted interactively using multimedia technologies. At workshops, students are given individual assignments to train the ability of making numerical assessments of environmental effect for both conventional and non-conventional power plants and obtaining the latest information on Global Climate indicators or required environmental data from available Internet resources, and deliver their

reports (in the form of presentation) on given topics. Learning materials are available to students through the OneNote Class Notebook.

Program of the course

Topics of the lectures

Objectives of the discipline

The value of this discipline for other professional disciplines. The amount of educational material, types of classes and organization of training.

Content module 1. Harmful impact of conventional power industry on environment

Topic 1. Sustainable development and international activity in environment protection

The UN Framework Convention on Climate Change. The Kyoto Protocol mechanisms. Greenhouse Gas Inventories. The Paris Agreement and its five key elements. Nationally Determined Contributions of the counties-parties. The key sources of GHG emissions.Dynamics of global GHG emissions and sustainable development scenarios.

Topic 2. Energy-related GHG emissions.

Dynamics of energy-related GHG emissions. Primary and secondary energy resources. Dynamics of global primary energy demand. Dynamics of global electricity demand. Scenarios of power industry development and electricity generation mix by 2050 and 2100. electricity generation mix by Склад твердого, рідкого та газоподібного викопного органічного палива та продукти його спалювання. Механізми утворення шкідливих речовин. Негативні впливи на природне середовище різних видів палива. Екологічні наслідки видобування вугілля, нафти та газу.

Topic 3. Thermal power industry impact on environment

Fossil fuel elemental composition. Combustible and non-combustible elements. Basic properties of coal, crude oil, and natural gas. Products of complete and incomplete combustion. Maximum permissible concentrations of harmful pollutants. Flue gas purifying systems. Liquid and solid wastes at thermal power plants.

Topic 4. Nuclear power industry and environment

Ecological impact of nuclear power plants. Nuclear fuel and fission. Volatile fission products and their treatment. Liquid and solid wastes of nuclear plants and their storage and disposal. Nuclear radiation and its effect on human health. Dose limits.

Topic 5. Noise, thermal, and electromagnetic pollution of the environment by power industry

Noise levels and its effect on people. The main sources of noise at power plants. Permissible noise exposures and sound control. Sources of thermal pollution at power plants. Impact of thermal pollution on the local environment. Electric and magnetic fields exposure at power plants and kines, safety measures.

Content module 2. Green technologies in power industry

Topic 6. Ecological effect of solar energy application

Global solar potential. Trends of solar power installed capacity trends and solar electricity share in electricity mix. Concentrated solar power, types and the main equipment of thermodynamic solar power plants. Photovoltaic power plants and their basic equipment. The basic characteristics of solar modules. Grid integration of a solar plant. Dynamics of capital costs and levelized costs of electricity from solar sources. Solar heating systems: solar ponds and solar collectors. Ecological benefits and shortcomings of solar systems.

Topic 7. Ecological effect of wind energy application

Global wind potential. Trends of wind power installed capacity and wind electricity share in electricity mix. Onshore and offshore wind farms. The basic characteristics of wind turbines. Classification of wind energy conversion technologies. Grid integration of a wind farm. Dynamics of capital costs and levelized costs of electricity from onshore and offshore wind. Ecological benefits and shortcomings of wind farms.

Topic 8. Ecological effect of wind energy application

Bioenergy resources. Bioenergy conversion technologies and facilities. Trends of bioenergy based installed capacity and bioelectricity share in electricity mix. Biogas technologies. Solid and liquid biofuel. Biomass co-firing. Anaerobic digestion technologies. Elemental composition of bio- and landfill gas. The

basic characteristics of a biogas plant. Dynamics of capital costs and levelized costs of biotechnology-based electricity. Ecological benefits of bioenergy application.

Topic 9. Hydropower and environment

Large-scale and small-scale hydropower. Trends of large-scale and small-scale hydropower capital investment and hydroelectricity share in the electricity mix. Types of hydroturbines and hydroplants. Dynamics of capital costs and levelized costs of hydroelectricity versus hydroplant scale. Ecological benefits and shortcomings of large-scale and small hydroplants. Complex utilization of water storage of a flat-land large-scale hydroplant. Marine power plants.

Topic 10. Cogeneration

Principle of cogeneration. Types and basic characteristics of cogeneration plants. Types of gaseous fuel fired in cogeneration plants. Capital costs and levelized costs of electricity produced by cogeneration plants. Ecological benefits and shortcomings of cogeneration. Trigeneration, its benefits and use.

Topic 11. Unconventional energy sources

Hydrogen production technologies and their ecological benefits and shortcomings. Heat pump systems, their application, and ecological benefits and shortcomings.

Topic 12. Distributed energy systems

Distributed energy generation and storage. Trends of distributed energy systems development. Environmental benefits and short-comings of distributed energy system. Financing of ecology-friendly technologies in power industry. Economic effect of ecology-friendly energy technologies implementation.

Topics of the workshops

Topic 1. The basic international documents on climate change

Some of the articles of the UN Framework Convention on Climate Change. The Kyoto Protocol and its mechanisms. The Paris Agreement.

Topic 2. Structure of Energy Balance, National GHG inventories, and Nationally Determined Contributions of a country

Student's presentation on sustainable development governmental documents (programs) in his/her country. Energy Balance, National GHG inventory, and Nationally Determined Contributions of Ukraine.

Topic 3. Assessment of consumed primary energy resources

Student's presentation on primary energy resources utilization and power generation structure in his/her country. Assessment of total amount of consumed primary energy resources (in oil equivalent) and total amount of CO2 emissions in the national power industry.

Topic 4. Estimation of products of combustion in the boiler

Student's presentation on primary energy resources utilization and power generation structure in his/her country. Estimation of products of combustion in the boiler produced by firing definite amount of fuel according to variants.

Topic 5. Estimation of thermal power plant flue gas pollutants

Student's presentation on flue gas cleaning facilities and techniques applied in his/her country. Estimation of flue gas pollutants produced by firing fossil fuel mix according to variants.

Topic 6. Assessment of thermal power plant chimney height

Student's presentation on the national legislation on environment protection, maximum permissible concentrations of air pollutants and environmental taxes in his/her country. Estimation of the thermal power plant chimney height according to variants.

Topic 7. Assessment of thermal power plant buffer zone

Estimation of maximum permissible emissions from the thermal power plant chimney, ground-level concentration of air pollutants and TPP buffer zone according to variants.

Topic 8.

Student's presentation on nuclear energy application and legislation, noise protection measures widespread at power plants in his/her country. Estimation of noise level caused by simultaneous operation of several power facilities located near each other.

Topic 9. Concentrated solar plant

Student's presentation on concentrated solar technologies applied in his/her (neighboring) country. Estimation of solar radiation on CSP heliostats in specified location and required receiver surface according to variants.

Topic 10. Ecological benefits of solar photovoltaic plant operation

Student's presentation on solar photovoltaic systems development in his/her country. Estimation of solar radiation on tilted surface in specified location, amount of generated electricity and ecological benefits of a PV plant according to variants.

Topic 11. Ecological benefits of solar heating system operation

Student's presentation on solar heating systems application in his/her country. Estimation of water volume heated by a solar collector system in specified location and ecological benefits of a solar plant according to variants.

Topic 12. Ecological benefits of wind farm operation

Student's presentation on wind power application in his/her country. Estimation of amount of generated electricity and ecological benefits of a wind farm according to variants.

Topic 13. Ecological benefits of biogas plant operation

Student's presentation on bioenergy application in his/her country. Estimation of amount of biogas produced by a methane-tank from specified biomass mix, selection of a relevant cogenerated plant to match the biogas production, and ecological benefits of the methane-tank-cogeneration system operation according to variants.

Topic 14. Ecological benefits of a small hydroplant operation

Student's presentation on hydro resources and hydropower development in his/her country. Estimation of amount of electricity and ecological benefits of a small hydroplant operation according to variants.

Topic 15. Ecological benefits

Student's presentation on unconventional energy technologies applied in his/her country. Estimation of amount of heat and ecological benefits of a heat pump system operation according to variants.

Topic 16. Students' presentations

Students' presentations on given topics.

Topics of the laboratory classes

This field is filled in the same way if the curriculum includes laboratory classes.

Self-study

Topics

Topic 1. The basic international documents on climate change. The contents of National GHG inventories, Nationally Determined Contributions

Topic 2. The main energy-related GHG emission sources, in particular, in the national power industry.

Topic 3. Environmental impact of thermal power industry. National legislation on human protection from environmental pollution by harmful products of fossil fuel combustion.

Topic 4. Environmental impact of nuclear power industry. National legislation on human protection from radiation exposure.

Topic 5. Noise, thermal, and electromagnetic pollution of the environment by power facilities. National legislation on human protection from these types of pollution.

Topic 6. Solar energy systems and their development in the national power sector.

Topic 7. Wind farms and their development in the national power sector.

Topic 8. Bioenergy systems and their development in the national power sector.

Topic 9. Hydropower development in the national power sector.

Topic 10. Cogeneration and trigeneration plants and their application in various fields of the national economy.

Topic 11. Unconventional energy systems and their applications in various fields of the national economy.

Topic 12. Distributed energy generation and storage, small-scale electricity supply grids.

Students are given individual assignments according to variants in practical classes.
Also, each student must prepare a presentation of a given topic.

Course materials and recommended reading

Compulsory.

1. The UN Framework Convention on Climate Change – Access: https://unfccc.int/resource/docs/convkp/conveng.pdf
2. The Paris Agreement – Access: https://unfccc.int/sites/default/files/english_paris_agreement.pdf
3. CO2 emissions from fue l combustion. Hightlights. [Electronic resource]. IEA, 2019. - 165 p. - Access: https://iea.blob.core.windows.net/assets/eb3b2e8d-28e0-47fd-a8ba-160f7ed42bc3/CO2_Emissions_from_Fuel_Combustion_2019_Highlights.pdf
4. Fuels and Combustion [Electronic resource]. IEA, 2019. - 165 p. - Access: https://www.academia.edu/35217952/Fuels_and_Combustion
5. Margit Löschau und Rudi Karpf. Flue Gas Treatment – State of the Art. [Electronic resource] IRRC – Waste-to-Energy, 12-13th October 2015, Vienna, 2015. - 27 p. - Access https://www.ete-a.de/img/Vortraege/50_Flue_gas_Treatment_-_State_of_the_Art.pdf
6. Concentrating solar power technology. Principles, developments and applications . Edited by Keith Lovegrove and Wes Stein. [Electronic resource] Woodhead Publishing Limited, 2012. – 701 p. – Access: https://www.sku.ac.ir/Datafiles/BookLibrary/45/Concentrating%20solar%20power%20technology_%20Principles,%20developments%20and%20applications-Woodhead%20Publishing.pdf
7. C.B.Honsberg and S.G.Bowden, "Photovoltaics Education Website", 2019. Access: https://www.pveducation.org/
8. Planning and Installing Solar Thermal Systems: A guide for installers, architects and engineers. Second edition. [Electronic resource], Earthscan Ltd, 2010, - 369 p. – Access: https://dokumen.pub/planning-and-installing-photovoltaic-systems-a-guide-for-installers-architects-and-engineers-2ndnbsped-1844074420-9781844074426-9781435616226.html
9. Ravi Kiran Karre, Kasangottu Srinivas, Khaja Mannan, B Prashanth, Ch.Rajendra Prasad. Review on hydro power plants and turbines [Electronic resource], AIP Conference Proceedings 2418, 030048. 2022, - 12 p. – Access: https://www.researchgate.net/publication/360839120_A_review_on_hydro_power_plants_and_turbines

Additional.

1. State of the Global Climate 2022 WMO-No. 1316. [Electronic resource]. - Access https://library.wmo.int/records/item/66214-state-of-the-global-climate-2022
2. World energy balances 2020: Overview. [Electronic resource]. - Access https://iea.blob.core.windows.net/assets/23f096ab-5872-4eb0-91c4-418625c2c9d7/World_Energy_Balances_Overview_2020_edition.pdf

Resources on the Internet

1. United Nations. Climate Change https://unfccc.int
2. International Energy Agency https://www.iea.org/
3. Climate Watch https://www.climatewatchdata.org/
4. International Renewable Energy Agency https://www.irena.org/
5. Europe's Energy Portal https://www.energy.eu/
6. World Meteorological Organization https://public.wmo.int/
7. Power Data Assess Viewer https://power.larc.nasa.gov/data-access-viewer/
8. Photovoltaic Geographical Information System https://re.jrc.ec.europa.eu/pvg_tools/en/#HR
9. World Wind Energy Association http://www.wwindea.org/
10. World Hydropower Association https://www.hydropower.org/
11 World Bioenergy Association https://www.worldbioenergy.org/
12 Green Hydrogen Organization https://gh2.org/

Assessment and grading

Criteria for assessment of student performance, and the final score structure

The final score consists of up to:
40 points for two module tests (20 points each),
30 points for 10 workshop assignments (3 points each),
10 points for the presentation,
20 points for the exam.

Defense of the calculated task is mandatory.

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

The student 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	Date, signature	Head of the department Oleksandr LAZURENKO
	Date, signature	Guarantor of the educational program Oleksandr LAZURENKO