The Master of Science degree program

**“Sustainable Thermal and Energy Systems”**

The purpose of the educational program " **Sustainable Thermal and Energy Systems”** is to prepare qualified specialists with professional knowledge, skills and abilities to solve the following tasks in the field of industrial heat and power systems and social sphere:

* to develop and maintain modern power engineering and heat installations;
* to develop and implement promising heat-and-power systems and appropriate equipment for them;
* to ensure rational use of fuel and energy resources at industrial enterprises and utilities;
* to conduct a feasibility study with justification of the priority directions for solutions of resources saving problems with a combination of centralized and autonomous power supply including the renewable energy sources usage;
* to create advanced life support systems at enterprises and housing;
* to develop mathematical models of studied objects for analysing their efficiency via modern computer programs;
* to ensure the environment protection.

The Master of Science degree program integrates the technology side of energy systems development with the financial planning needed to effectively implement them. The goal of the educational program is to create a high-level signature, interdisciplinary graduate program for the engineer or technical business major, who is pursuing an industrial or public planning based career.

The program curriculum is firmly rooted in energy technology and includes exposure to the interface with business and financial decision processes. Practicing professionals with experience at this interface who have successfully implemented energy systems or devices and policies are actively involved in the program as faculty and invited speakers.

The curriculum is flexibly designed with a set of a number of core courses in engineering knowledge and finance, including "Energy Efficiency Increasing Methods", "Impact Pathways Analysis", "World Energy Development Prospects", "Business Planning in Power Engineering" and etc. Through this curriculum and interaction with practitioners, our students are prepared to effectively integrate energy system development over a broad spectrum of technologies with specific financial requirements to successfully implement them and compete in the global energy market.

Graduates of the program will be involved in the decision making or policy planning that will deliver sustainable, energy efficient systems to the global market. They will have the basic training necessary to lead efforts within companies to plan and implement new energy generation investments, realize energy efficiency improvements specifically at the system level, and participate in energy and environmental markets such as, heat and power purchase agreements, energy management monitoring and cap-and-trade systems.

Essentials:

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| General requirements  | Degree of Bachelor / Specialist / Master in a related area of expertise. English language proficiency at B+.  |
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| Start of studies  | September, 1  |
| Duration of studies  | 2 years (4 semesters)  |
| Total ECTS  | 120 ECTS  |
| Degree  | MSc  |

**Modules of the program**

**Fundamentals of Systems Analysis and Design**

*Lector – PhD, senior lecturer, Maskinskaya Anna Yurievna*

The module is 3 credit units.

System analysis, as for a practical point of view, is a universal method of solving some complex problems of different aspects points. Definition and diagnosis of problems in many complex systems are the most important. They define goals and objects of the system analysis and also methods and algorithms which will be used in future for making decisions. With that there are the most difficult and the least formalized stages.

System analysis is used in any institution management. It is difficult to overestimate the analysis value in managing. Being positive, on the base of the system concept position any management summarizes all methods of influence on object for achieving the given goals, which are based on the information of the object behavior itself and also state of the neighborhood systems. Depending on the situation, in theory each researcher ought to find basic principles and analyze them. So, system analysis was being improved in time and the field of its application was being changed. With that problems at different areas were being developed and solved.

The different methods of analysis for studying and developing the heat power engineering and social systems will be studied and discussed at the present course.

**Energy saving contemporary issues and sustainable development**

*Lector – PhD, associate Professor, Gasho Evgeniy Gennadievich*

The module is 4 credit units.

The purpose of the course is to give an idea of the energy efficiency of different industries and the municipal complex of cities. The ability to apply modern research methods, evaluate and present the results of the work performed, formulate the goals and objectives of the study, identify priorities for solving problems, select and create evaluation criteria. The indicators of the energy efficiency of industrial production and urban systems are closely related to the sustainable and balanced development of the economy. As a result of studying the discipline, listeners get an idea and interrelations of energy efficiency and indicators of sustainable development. The latest data on the conducted energy inspections of enterprises, the results of the implementation of energy-saving production plans and programs for energy-intensive industries.

**Impact Pathways Analysis**

*Lector – Dr.Sc., Professor, Sultanguzin Ildar Aidarovich*

The module is 4 credit units.

The environmental safety and power effectiveness of power supply systems of cities, large industrial enterprises and regions of the country are considered. Original positions of methodology of the sequence of impact of harmful emissions on environment by the Impact Pathways, which is applied in many countries of the world when developing the new pollution-free power technologies are stated. Problem definition of optimization of the electric and thermal energy production system in the region by environmental and energy criteria is formulated. Examples of increase of power and environmental effectiveness of the electric and thermal energy production systems at various combined heat and power plants using natural gas and coal fuel, biomass and also at the large industrial enterprises, such as integrated steelworks are given.

The problem of harmful emissions from the automotive vehicles, their dispersion in environment and impacts on population health of large cities is analyzed. For heat pumps solutions of a problem of creation of eco-friendly new generation refrigerants with low global warming potential, prediction and calculation of thermodynamic and thermal characteristics of the refrigerants are analyzed and offered.

The software package of calculation of harmful emissions dispersion and impact on population health at the local level from point sources is ISC Manager, and from the vehicles is CALINE Manager , and also at the regional level is ECOSENCE are used for tutoring.

The course “Impact Pathways Analysis” is intended for students and postgraduate students who are interested in questions of development of thermal engineering systems and decrease of impact of harmful emissions on environment.

**Economy and business planning in industrial power engineering**

*Lector – PhD, associate Professor, Savchenkova Natalia Mikhailovna*

The module is 4 credit units.

The main aim of the course «Economy and business planning in industrial power engineering» is to obtain professional knowledge and skills in the development of forms and methods of economic management of enterprise in industrial power engineering in market economy, acquisition of skills of the independent initiative and creative using of theoretical knowledge in practical activities, formation of business planning of skills for students, knowledge of the project management methods in industrial power engineering, skills to draft project documentation (investment application, business plan etc.).

The following questions are considered in this course:

* Design of construction in industrial power engineering.
* Production facilities of the power engineering enterprise.
* Prime cost of energy. Formation of tariffs.
* Realization, profit and profitability of energy in industrial power engineering enterprises.
* Methods of evaluation of investment efficiency.
* Absolute financial and economic efficiency of investments in facilities of industrial power engineering.
* Evaluation of the project financial solvency.
* Financing of industrial power engineering facilities.
* Financial facilities of energy companies.
* Risk assessment.
* Classification and features of various types of business projects.
* The main business technologies for implementation of investment projects in industrial power engineering.
* Studying the ways of organizing and implementing the investment tasks.
* Optimization of using the resources to achieve the desired results by using business planning technologies in industrial power engineering.
* Acquisition of knowledge and skills in the field of description and modeling management of business projects.
* Mastering the grounds of project management industrial power engineering.

**Automated control systems for technological processes in heat power engineering, heat engineering and heat technologies**

*Lector – PhD, associate Professor, Merzlikina Elena Igorevna*

The module is 5 credit units.

This course is studied in the first term of the master study and consists of 18 lectures and 9 laboratory works, at the end of the term students pass their exam, and if they are success, they get 5 credits for the whole course.

The aim of the present course is to familiarize the students with the modern situation in automation in heat power engineering, heat engineering and heat technologies, main approaches to the control and monitoring systems development, hardware and software on the basis of which the systems mentioned are built.

The first part of the course is devoted to measurements and measuring instruments. Students study direct and indirect measurements and measurement errors. Then they study measuring temperature, pressure, flow and level, some chemical parameters (pH, electrical conductivity etc.) and also heat and inner structures of some measuring devices.

In the second part of the course some matters of the process control theory are considered. This part mostly deals with linear control systems, their mathematical models (differential equations, transfer functions, time and frequency characteristics), linear systems stability and linear controllers tuning. MIMO-systems, digital and non-linear systems are considered briefly.

The third part of the course concentrates on industrial control systems, their structure, functions, subsystems and approaches to their development. The information subsystem, alarm and protection systems are considered as well as issues of their reliability. Some attention is also paid to hardware, i.e., controllers and actuators and some other devices, and software, i.e. programming systems and languages, and SCADA-systems.

In addition to the lectures students have 9 lessons in laboratories where they get practical skills based on the lectures material. At first students work with measuring devices, study their inner structure and approaches to verification. The second part of the laboratory lessons is dedicated to control systems simulation and tuning by means of Matlab/Simulink. Finally, students work with small control systems based on real controllers and actuators.

**Mathematical modeling and optimization of energy systems**

*Lector – PhD, associate Professor,Kurzanov Sergey Yurievoch*

The module is 4 credit units.

# The educational course contains main system analysis; mathematical models of design and optimization methods of complex thermal engineering system. It is designed for students majoring in the "Industrial heat- and power engineering" direction. The course is useful for students of heat and power specialties to perform analysis and researching of heat and power systems.

# The course includes the following issues:

# General concepts of systems theory.

# Mathematical modeling.

# Graph method for creating mathematical models based on balance equations.

# Construction of a mathematical model of heat and power installations.

# Mathematical modeling of gas turbine power plants.

# Application of optimization techniques in engineer practice.

# Methods of optimization. Examples.

# Application of methods of mathematical statistics and probability theory to build mathematical models.

**Heat and mass transfer industrial facilities**

*Lector – Dr.Sc., Professor,* *Garyaev Andrey Borisovich*

The module is 4 credit units.

The course is intended for MPEI students of the heat power engineering specialities. The purpose of the course is to give students knowledge on different types of heat exchangers and their design features. It consists of two main parts: heat exchanging installations and heat utilizing ones.

Three types of heat exchangers are studied in this course: direct-contact heat exchanger (open-type heat exchanger) and surface type heat exchangers – recuperators and regenerators, as well as different constructions of apparatus their design specifics.

Recuperators are represented in the course by heat and shell heat exchangers, plated heat exchangers, finned tube heat exchangers and heat pipes with different heat transfer agents. Students will be able to make designing or checking calculation, to perform heat balance, heat capacity, heat transfer area and coefficient of heat exchangers, to evaluate electric capacity of heat transfer agent pumps. Wet air coolers design specifics will be also considered.

Heat utilizing devices including dryers, scrubbers, vaporizers, distillatory kettles, rectifying columns also are reviewed.

**Hydrogen and electrochemical power systems**

*Lector – Dr.Sc., Professor, Kuleshov Nikolay Vasilevich*

The module is 6 credit units.

The purpose of the program is acquaintance of students with fundamentals of hydrogen and electrochemical power systems, calculation of their key parameters and analysis of the processes proceeding in them. Physicochemical properties of hydrogen, aspects of its application in industry and power generation sector will be considered within the framework of the educational course.

 Lecture course will cover the methods of production, storage and utilization of hydrogen for electricity and heat generation. In particular, water electrolyzers and hydrogen/alcohol fuel cells of various types, systems of hydrogen storage of in gas, cryogenic, chemically-bound and adsorbed conditions are considered. Issues of chemical thermodynamics and kinetics, constructional, thermal and hydraulic calculations of electrolysis and fuel cell stacks, modeling of current-voltage characteristics and so on are mastered in the course of practical studies.

**Statistical methods for scientific research**

*Lector – Dr., Professor, Agamirov Levon Vladimirovich*

The module is 5 credit units.

The purpose of the module is the acquisition of knowledge and skills in the collection, processing and analysis of statistical data obtained in the process of laboratory and full-scale testing of structural elements of aircraft, as well as during operation. The study of statistical methods for estimating reliability and resource based on the results of laboratory and full-scale tests in the conditions of static and variable loading of force elements of aircraft structures is performed.

The main parts of the course are the following:

* Statistical methods for estimating random variables based on the results of sample populations.
* Full and incomplete (censored and progressively censored) samples, the causes and consequences of their formations in the analysis of failures of elements of aircraft structures.
* The methods of processing samples (likelihood estimations and least squares).
* Trustful estimation of parameters and quantiles of distribution of random variables under censorship conditions, justification of the guaranteed resource of critical structural elements on this basis.
* Criteria for testing statistical hypotheses used in analyzing the laboratory results, field tests and aircraft failures, nonparametric criteria, and robust procedures.
* Features of processing the results of fatigue tests of materials and structural elements for direct and indirect (construction of fatigue curves and distribution functions of endurance limits) tests.

**Energy audit and energy saving of industrial enterprises**

*Lector – PhD, associate Professor, Gorelov Mikhail Valentinovich*

The module is 5 credit units.

 Purposes of the module are to review modern normative documents about energy saving, techniques of calculation of energy saving potential and development of energy saving programs.

Summary of sections:

* Normative documents on energy saving in Russia, EU, China, USA, etc.;
* Industrial energy audits;
* Types of energy audit;
* Measuring and professional equipment;
* Typical ways to improve energy efficiency of industrial enterprises or in buildings;
* Safe, efficient, affordable and environmentally friendly energy generation;
* Development of energy saving programs to improve energy efficiency.

**Indoor microclimate analysis and design**

*Lector – PhD, associate Professor, Gorelov Mikhail Valentinovich*

The module is 5 credit units.

This module aims to convey knowledge of development of indoor microclimate systems.

Summary of sections:

* Normative documents about development of indoor microclimate systems in Russia, EU, China, USA, etc.;
* Processes in the I-d diagram (heating, cooling, air drying, air humidification);
* Determination of efficiency of the microclimate system;
* Typical ways to improve energy efficiency in indoor microclimate systems (recycling and recuperation of outlet air, heat pump, using two heat exchangers with an additional heat carrier);
* Main equipment (dust filter, heat exchanger, humidifier, fan, noise suppressor, air duct);
* Design of aerodynamics and selection of fans.

**Сomputer aided design of heat power engineering systems**

*Lector – PhD, associate Professor, Yavorovsky Yury Viktorovich*

The module is 5 credit units.

The purpose of the academic subject learning is to give students the principles of designing the heat power engineering (HPE) systems, grounds of design and project activities in industrial heat power engineering. Knowledges in the sphere allows students to solve a range of practical questions connected with design of the energy efficient heat power engineering systems and units in industrial sphere and utilities.

The course is devoted to studying the following questions:

• regulatory documents when designing in the industrial heat power engineering sphere (1), requirements for composition of project and technical documentation (2), registration rules for final documentation and its structure (3), the basic points of legislation for design and project activity in heat power industry, heat engineering and applied thermal technologies.

• common principles of designing industrial heat power engineering systems and thermal units;

• set of requirements for designing HPE systems on industrial enterprises, the main steps of performing the given project;

• acquisition of knowledge on methods of gathering the necessary technical information for design of HPE systems;

• methods applied in designing of systems and units in industrial heat-power engineering;

• estimating and analysing the economic parameters and costs;

• computer-aided design;

• systems of geometric modeling HPE systems;

• automated calculations in designing.

**Fuel supply systems**

*Lector – PhD, associate Professor, Zhigulina Ekaterina Valerievna*

The module is 5 credit units.

The purpose of the discipline is to shape knowledge about modern technologies

and processes relative to the designing and calculating of different types of fuel supply systems.

Tasks of discipline: to examine the destination and structure of the gas pipeline, the

characteristics of the gas and gas transportation process flow diagrams at different

stages of the process of transportation, the method of choice of modern vehicles

and justify their operational parameters; to practice skills of designing and evaluating

the organizational and technical level of technological schemes and means of

transportation of natural gas, to learn the properties of solid and liquid fuels and characteristics of these types of fuel supply systems, to learn the peculiarities of liquefied natural gas production, transportation, storage and usage.

Main didactic units:

* An overview of the pipeline transportation of gas.
* The current state and problems of pipeline gas.
* Structure and apparatus for gas transportation pipelines. Liquified natural gas usage.
* Fundamentals of calculating the parameters of gas pipelines.
* Hydraulic calculation of the gas pipeline.
* Thermal design of gas pipelines.
* Features accurate calculation of optimum parameters of gas pipelines. Solid fuel supply system. Liquid fuel supply system.

**Thermal engineering software**

*Lector – PhD, associate Professor,* *Fedyukhin Aleksandr Valerievich*

The module is 5 credit units.

The module suggests the guidelines for the modeling of main technological processes used in industrial power engineering. It describs step-by-step examples of energy, oil and gas equipment computation using advanced software systems such as Aspen Plus, Aspen HYSYS, Aspen Energy Analyzer, THERMOFLEX.

Training contains the basic modeling of various power plants including: combined cycle power plant, gas turbine, heat pump, solid fuel gasifier, distillation column, organic Rankine cycle. It deals with the questions of energy optimization regarding to the following technology characteristics: efficiency, the consumption of air and natural gas for effective combustion and etc. Modelling includes the calculation of the auxiliary equipment and components: heat exchangers (heaters, coolers, reboilers, condensers, air coolers), pumps (feed, district heating, technology), compressors, turbines (steam, gas), reactors. Additionally, the course analyzes the features of each software module in comparison with similar programs.

The module is designed for students being learned the specialty "Industrial heat and power engineering".

**Mathematical modeling of heat and hydrodynamic processes, equipment and systems in industrial heat power engineering**

*Lector – PhD, associate Professor,* *Glazov Vasily Stepanovich*

The module is 5 credit units.

The purpose of learning the course is to study the principles of modeling and also to get skills to solve the heat and mass transfer tasks in industrial heat power engineering systems. Training is accompanied by studying the special scientific-intensive software packages (SISP), designed for calculation and simulation of heat power engineering systems and also processes in their units for power generating and power using equipment. Under studying, specific examples describe how to use software packages to conduct computing experiments in order to adequately reproduce question under study, to analyze and compare the numerical results with the theoretical and experimental data.

Tasks of the course are the following:

• To give information about main issues in the field of modeling the heat-exchange liquid and gas flows over surfaces;

• To work out skills to calculate effectiveness of heat energy removing from the heat-transfer surface under intensive heat exchange;

• To study (optionally) SISP applied for calculation, design and simulation of heat power engineering and heat power technology facilities;

• To work out skills in applying SISP (AnSys Fluent, COMSOL, PHOENICS, MatLab, Waterloo maple, Wolfram Mathematica, etc.) to solve practical problems at various fields of industrial heat power engineering systems.