3

Qualifications in Environmental Engineering

The typical degrees offered within this subject area in the Russian Federation are presented in Table 1.

Table 1
Typical degrees in Environmental Engineering

Cycle	Degrees	Qualification awarded	ECTS credits
1st cycle	"Energy and resource processes in chemical engineering, petrochemical and biotechnology" Specialisations: • "Environmental protection and sustainable use of natural resources". • "Rational use of raw materials and energy resources." "Technospheric security" Specialisations: • "Environmental Engineering " • "Protection of the environment and resource conservation"; • "Safety in Technosphere" • "Safety of technological processes and production"; • "Protection in Emergency Situations"; • "Radiation and electromagnetic safety"	Bachelor	240

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Cycle	Degrees	Qualification awarded	ECTS credits
2nd cycle	"Energy and resource processes in chemical engineering, petrochemical and biotechnology" Possible master's programs: • "Industrial ecology and management of natural resources" • "The protection of the atmosphere from anthropogenic impacts"; • "Integrated water resources"; • "Protection of the lithosphere of technological impacts"; • "Waste management and recycling of production and consumption." "Technospheric security" Possible master's programs: • "Modelling and control of environmental systems"; • "Information Technology in Environmental Protection"; • "Monitoring areas with high anthropogenic load"; • "Environmental and economic examination and licensing of industrial enterprises"; • "Predicting and managing the consequences of environmental emergencies • "Methods of control of the environment and ecological instrument." "Waste management and recycling of production and consumption."	Master	120
2nd cycle	"Protecting the environment" Possible specialisations: • "Environmental protection and rational use of natural resources"; • "Environmental Engineering" "Technospheric security" Possible specialisations: • "Safety in Technosphere" • "Safety of technological processes and production"; • "Protection in Emergency Situations"	Specialist	At least 300

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Further analysis of the survey responses in the subject group allowed revealing most important general competencies for undergraduate subject area "Environmental Engineering" and reducing the list to 9 competences:

Table 4
Generic competences for subject area Environmental Engineering

New code	Generic competences
GC 1	Ability to work in a team
GC 2	Capacity to generate new ideas
GC 3	Ability to apply knowledge in practical situations
GC 4	Skills in the use of information and communications technologies
GC 5	Ability to work autonomously
GC 6	Ability to plan and manage time
GC 7	Ability to evaluate and maintain the quality of work produced
GC 8	Knowledge and understanding of the subject area and understanding of the profession
GC 9	Ability to resolve conflicts and negotiate

5.2.3. Subject specific competences

The basis of subject-specific competences is represented by skills that enable the graduate to participate in the process in accordance with the regulations to use technical means for measuring the parameters of raw materials and products, to substantiate the specific technical solutions in the design technological processes, to choose the equipment and technologies directed towards minimizing human impact on the environment. At the end of the programme a graduate must have a full set of subject-specific competences, which reflect differences in the content of existing trends and profiles of education.

These competences are acquired in the course of the study of special professional courses. After the completion of the educational programme

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- N.I. Lobachevsky State University of Nizhni Novgorod (UNN).
- North Caucasus Federal University (NCFU).
- Udmurt State University (UdSU).

Initially the group analyzed 24 standards headed by TMA Engineering, as follows: 190300 "Rolling stock of railways," 190401 "Operation of Railways," 190901 "System to ensure the movement of trains," "271501 "Construction of railways." As a result, the group identified the knowledge, skills and abilities that are common to all disciplines of engineering qualifications.

The agreed list of general engineering and specific professional competences was presented at the First General Meeting of the project Tuning Russia in DSTU in April 2011.

Subject-specific competences consist of 25 items, the first 13 of which correspond to the general engineering competences, which any engineer should have after completion of degree programme, regardless of the direction of specialization, and numbers 14 to 25 are items related to the subject-specific competences for the subject area Environmental Engineering.

Table 5
Subject specific competences for Environmental Engineering

Competence code	Competence definition
SC 1	Ability to apprehend, accumulate, analyse and use fundamental and applied knowledge in technical, engineering and natural sciences, using modern information technologies
SC 2	Ability to participate in theoretical and experimental research using mathematical computation and modelling methods, technical devices, controlling and measuring apparatus, etc.
SC 3	Knowledge and understanding of the role and status of engineering as a profession in the social-economic development of the society and impact of engineering solution in a global context

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Competence code	Competence definition
SC 4	Possessing of methods of visualization of technical objects by graphical representation and 3D geometric simulation, using computer technologies
SC 5	Ability to participate in creating, implementing, and using technical objects and technologies through all stages of their life cycle
SC 6	Ability to detect an engineering problem and to select a typical or nonstandard method of solution
SC 7	Ability to use existing and develop new technical methods, technologies and equipment for the solution of engineering problems
SC 8	Ability to design and conduct experiments, as well as to analyse and to interpret data
SC 9	Ability to receive profound knowledge in one or more areas of engineering. Aptitude for life-long learning and professional skills improvement
SC 10	Knowledge of methods of the preservation and reproduction of basic technical systems and technologies
SC 11	Possessing of knowledge in interdisciplinary areas
SC 12	Ability to examine technical objects and technologies
SC 13	Ability to think strategically, identify, model and construct original engineering systems, elaborate unique and advanced technologies
SC 14	Ability to understand mechanism of anthropogenic influence on biosphere – *be able to understand the biosphere processes and influence of human being and technical and engineering systems on them*
SC 15	Ability to formulate and defend a position in ecological discussion – *be able to understand the various points of view, to formulate one's own point of view and to maintain that position in discussion on environment protection*
SC 16	Ability to understand the interrelation of scientific and technical progress and environmental protection – *be able to understand trends in techniques and technological development, scientific and technical process as a whole and its influence on the environment*

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Competence code	Competence definition
SC 17	Ability to apply principles of rational nature management – *be able to apply knowledge of the basic regularities of the functioning of the biosphere and principles of rational nature management for solving the problems in the field of environmental engineering*
SC 18	Ability to measure environmental parameters – *apply basic technical equipment and equipment used for environmental monitoring*
SC 19	Ability to predict a state of environment – *be able to analyse physical, chemical and biological anthropogenic impact on the environment and to predict its consequences*
SC 20	Ability to apply the requirements and norms of ecological legislation – *be able to apply requirements and norms of the ecological legislation and ecological standards in practice*
SC 21	Ability to identify and solve problems of environmental protection – *be able to understand, analyse and solve problems of environment protection from anthropogenic impact*
SC 22	Ability to carry out the techno-ecological analysis – *be able to carry out the techno-ecological analysis of economical activities and technical documentation*
SC 23	Ability to apply principles of ecological safety – *be able to apply main principles of ecological safety for protection of industrial personnel and the population at large from the possible consequences of failures and accidents*
SC 24	Ability to formulate problems of ecological design – *be able to formulate tasks for the survey and design works in accordance with requirements of environmental protection and rational nature management*
SC 25	Ability to understand the impact of technical solutions in a global environmental context

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5.2.4. Meta-profile

A Meta-profile reflects the structure and the interrelation of competences that characterise a particular subject area. Meta-profiles are used for reference, to depict mental models and should demonstrate the variety of possible and existent degree profiles within a particular subject area. Meta-profiles and meta-competences are determined by analysing stakeholder-consultation results through re-categorising the list of competences. Such re-categorisation can be done differently in different subject areas and should reflect the subject area unique characteristics.

5.2.4.1. Meta-competences

Due to the large number of general and subject-specific competences that need to be implemented in the subject area, it is useful to carry out the procedure of re-categorization. It is possible to identify the key competences that at a certain level should be achieved by any graduate of a Bachelor's degree in a given subject area, regardless of the profile (orientation) training, or group competences into larger structures - the meta-competences, denoting their specific terms. The achievement of key skills (meta-competences) should be an input requirement for applicants to master's programmes in a given subject area.

From meta-competences a meta-profile can be generated - a general understanding of a subject area, enabling its general identification and, at the same time, leaving the freedom to develop and implement educational programmes in specific areas of training and specialization in different universities.

Individual sets of meta-competences can have different contents, but they give the tools to compare the contents of a bachelor's in one subject area and provide learners with academic mobility.

A meta-profile is part of a consensus; it is a combination of general and specific competences with the general and specific competences being in interaction.

An analysis of the list, after the reduction of general and subject-specific competences in the subject group "Environmental Engineering", has shown the feasibility of formulating four enlarged meta-competences at bachelor's level. One of them, GCM 1, includes all 9 general competences,

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which enable graduates to work at a high level in any production team and in any capacity, and to interact with specialists in other subject areas. Three meta-competences are made up of subject-specific competencies on the basis of their reference to different levels of engineering education: basic, applied and specialized in a specific area:

- SCM 1 - The ability to generate and use basic engineering knowledge (including competence SC 1 - The ability to receive, collect, analyse and use basic and applied knowledge in the field of technical, engineering and science, including the use of modern information technology; SC 2 - Ability to take part in the theoretical and experimental studies using mathematical calculations and modelling methods, technical equipment, test equipment, etc.; SC 3 - Own the technical methods of imaging objects using graphic images and three-dimensional geometric modelling, including the use of computer technology ; SC 5 - The ability to identify engineering problems and pick up the typical or standard solution; SC 12 - The ability to understand the impact of the adopted technical solutions for global environmental context.
- SCM 2 - Ability to identify and solve an applied engineering problem (competences SC 4 - The ability to participate in the creation, implementation and operation of the technical facilities and technologies at all stages of their life cycle; SC 8 - The ability to measure environmental parameters; SC 9 - The ability to apply the requirements and standards of environmental laws).
- SCM 3: The ability to identify and solve specific problems in the field of environmental protection (competence SC 6 - Ability to understand the mechanism of human impacts on the biosphere; SC 7 - The ability to apply the principles of environmental management; SC 10 - The ability to understand and solve environmental problems; SC 11 - The ability to conduct technical and environmental analysis).

This approach to the re-categorization of general and subject-specific competences demonstrates that, in the subject area of "Environmental Engineering", there is no predominant influence of any set of skills or meta- competences. They all complement each other and together can provide comprehensive training for students, a high level of graduates, and assure their compliance with modern requirements for specialists with higher education and with labour market needs.

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The first meta-competence is composed of subject-specific competences related to the fundamental, basic engineering training, regardless of further specialization, which are presented in the following table:

	Mathematics	physics	chemistry	informatics	ecology	Descriptive geometry. Engineering Graphics	mechanics	Electronics and Electrical Engineering
SC 1	+	+	+	+	+		+	+
SC 2	+	+	+	+	+		+	+
SC 3				+		+	+	
SC 5				+		+	+	+
SC 12		+	+		+			

Fundamental, basic disciplines for the area "Environmental Engineering" form the following general and subject-specific competences:

	GC 3	GC 8	GC 9	SC 6	SC 7	SC 9	SC 10	SC 12
Ecology	+	+		+	+		+	+
Earth Science	+	+		+	+		+	+
Human Physiology	+	+		+				
Toxicology	+	+		+				
Environmental Law	+	+	+			+	+	+
Environmental Management	+	+	+		+	+	+	+

The ability of future engineers to identify and solve specific problems in the field of environmental protection is defined in the following block of relevant disciplines and competences:

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	GC 3	GC 5	GC 8	SC 6	SC 7	SC 8	SC 9	SC 10	SC 11
Metrology, standardization and certification	+	+	+			+	+		
The reliability of technical systems and technological risks	+	+	+	+			+	+	
The sources of environmental pollution	+	+	+	+			+	+	+
Technique and environmental technology	+	+	+	+	+	+	+	+	+
Methods and tools for measuring the quality of the environment	+		+	+		+	+	+	
Low waste and resource-saving technologies	+	+	+	+	+	+	+	+	
Environmental impact assessment	+	+	+	+	+		+	+	+

Below are detailed descriptions of generic and subject-specific competencies that are essential for bachelor level "Environmental Engineering".

Competence GC 6: Ability to Plan and Manage Time

1. Description

Competence, "The ability to plan and allocate their time," describes the ability to determine correctly the amount of specialist work, a rational sequence of steps, the actual terms of performance, the ability to engage in various activities in the same period of time in an organized and regular manner.

2. Interaction with other competences, attitudes, interests, values

The most intimate connection of competence "ability to plan and allocate their time" can be traced to the general and subject-specific competences:

GC 1 – Ability to work in a team.

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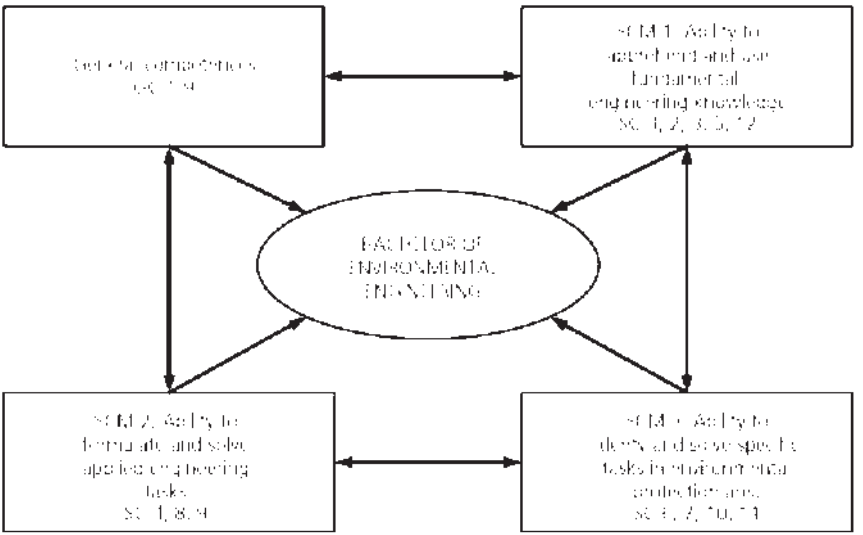
5.2.4.2. Diagram of meta-profile



Graph 5
Diagram of meta-profile for Environmental engineering

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First-cycle graduates (Bachelors) should:

Cycle	Learning outcomes
1st cycle: Bachelor	Graduates of the first level (bachelors) need to know / understand: the basics of the legal system and legislation, legal, moral and ethical standards in the field of environmental protection, the basic concepts and methods of mathematics, hardware and software implementation of information technology, basic concepts, laws and relations in physics, chemistry, physiology, basic properties of the classes of chemical compounds, bases of interaction of living organisms with the environment, the natural processes in the atmosphere, hydrosphere, lithosphere, factors that determine the stability of the biosphere, characteristics of human impact on the environment, global environmental problems, the main principles of the organization of production processes, methods to assess their effectiveness and impact on the environment; economic basis for the organization of production; framework to protect the environment from various dangers. Bachelors should know / be able to do: to use ethical and legal standards governing the relationship of man to man, society, environment, to use the physical and chemical laws in analyzing and solving the problems of energy and resources, to carry out the analysis and statistical processing of the results of analytical determinations , to assess the technological and economic efficiency, environmental security, to carry out a general assessment of human impact on the environment, to identify hazardous and extremely hazardous areas, zones of acceptable risk, to choose the means of protection for specific tasks to ensure human safety, to determine the cost-effectiveness of measures to safety and the environment. Bachelors should know: the basics of economic and environmental law, management practices of primary operating units, methods of finding and sharing information on computer networks, methods of physical and chemical measurements and correct assessment of their errors, and methods of monitoring and control of environmental parameters, methods of assessment of environmental and economic damage caused by the activities of enterprises, methods of choosing a rational way to minimize the impact on the environment, methods for dealing with emergency and emergency situations.

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Cycle	Learning outcomes
2nd cycle: **Master**	Graduates of the second level of HPE (Masters) need to know / understand: the main research areas and concepts, methods and techniques of scientific research, advanced mathematical methods for solving various problems, principles and methods of system analysis, modeling principles of technological and natural processes, modern computer and information technology, used in the field of environmental protection, methods of technical and economic analysis of protective measures, techniques and technologies to protect the environment and people from human impact. Masters should be able to ÷ to plan and carry out scientific research, effectively choose the best computer technology, to create new methods and systems for the protection of man and the environment, to analyze patent information, to develop and implement innovative projects in the field of environmental protection and human rights; to evaluate and predict the economic effects and consequences of on-going and planned processes. Masters should possess: a methodological analysis of the skills of scientific research and its results, the skills to use software packages in the field of environmental protection, ecological and economic methods of analysis and planning, safety management techniques in the technosphere, skills teaching activities.

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