

The concept of creating a multi-level specialized scientific and educational direction "Nuclear Engineering" at the University of Belgrade

INTRODUCTORY PART (ABSTRACT)

The proposed Concept for the Creation of a Specialized Scientific and Educational Program in Nuclear Engineering at the University of Belgrade represents a strategic interdisciplinary project aimed at reviving and long-term developing the human and scientific potential of Serbia's nuclear industry. The program was developed in the context of long-term nuclear project implementation cycles and the global nature of NPP construction by international consortia, necessitating the development of competencies in graduates that ensure professional mobility and competitiveness in a multi-regulatory environment.

The key fundamental principles of the Program are:

- **Technological indifference (vendor independence):** Focus on fundamental principles and systems engineering, providing a deep understanding of various nuclear technologies (including small modular reactors - SMRs) and multi-platform comparative analysis, giving Serbia flexibility in choosing technology partners.
- **Interdisciplinarity and integration:** Combining the efforts of the Mechanical Engineering, Electrical Engineering, Technological, Physics, Civil Engineering and other faculties, as well as specialized scientific institutes (Vinca), with the active participation of the regulatory body (SRBATOM) and specialized ministries.
- **Practical focus and unique competencies:** Implementation of specialized training modules on **Nuclear Construction Management**, site preparation engineering, as well as critical aspects such as **welding technologies and weld quality control**.
- **Multi-normative competence:** Developing in-depth knowledge of navigation and operation within a variety of national and international safety and design standards.
- **Synthesis of international experience:** Interaction with strategic partners, including France (under the cooperation agreement with EDF/INSTN/CEA) and China, in adapting best global practices to Serbian specifics.

The program is implemented across three consecutive levels of education in accordance with the Bologna Process and ECTS standards: **Basic Academic Studies (Osnovne akademske studije — Bachelor's degree)**, **Master's Academic Studies (Master akademske studije)**, and **Doctoral Academic Studies (Doktorske akademske studije — PhD)**. The program's structure is based on a clear academic hierarchy (Degree Program -> Levels -> Curricular Blocks -> Courses -> Task Blocks -> Tasks), ensuring a systematic and continuous learning experience. Particular attention is paid to integrating students with non-core backgrounds through bridge programs and the synergy of interdisciplinary backgrounds.

The final section of the Concept defines a roadmap for further actions, including the detailed development of Syllabi and Modules, formalization of cooperation between participants,

active engagement with industry, infrastructure provision, international partnerships, as well as the accreditation process and the implementation of an internal quality monitoring system. The implementation of this Concept is a fundamental guarantee for the successful development of sustainable human resources and ensuring technological independence in the Serbian nuclear energy sector.

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SECTION 1. GENERAL PROVISIONS

1.1 Introduction and Relevance

These Regulations define the fundamental principles, organizational principles, and strategic development directions **of the specialized scientific and educational module in nuclear engineering (hereinafter referred to as the Module)** . The Module is considered a critical element of the national infrastructure for ensuring technological independence, energy security, and sustainable development in the context of the global energy transition.

The development of nuclear energy requires the creation of a sovereign system for training highly qualified personnel capable of ensuring the safe, efficient, and long-term design, construction, operation, and decommissioning of nuclear facilities.

1.2 . Goals and Strategic Objectives

The Module's primary goal is to develop a sustainable scientific and educational ecosystem that ensures the reproduction of competencies, the conduct of advanced scientific research, and integration into the global nuclear energy community.

Key strategic objectives of the Module:

1. **Staffing:** Training a new generation of engineers, researchers, and managers for all stages of the nuclear facility life cycle.
2. **Scientific and technical potential:** Conducting fundamental and applied research in the field of reactor physics, nuclear safety, new materials and the fuel cycle.
3. **Technological independence:** Reducing dependence on imported technologies and services in critical areas of nuclear engineering.
4. **International integration:** Participation in international scientific and educational projects while respecting national interests.
5. **Safety and Resilience:** Building a safety culture and ensuring the long-term sustainability of the state's nuclear program.

1.3. Fundamental Principles of Organization

The creation and operation of the Module is based on the following principles:

1. **Safety Principle:** Nuclear safety culture is the highest priority in all activities - educational, scientific and operational.
2. **Interdisciplinarity Principle:** The module combines knowledge in the fields of physics, mathematics, chemistry, materials science, engineering and ecology.
3. **The principle of "Science through Education":** The educational process is inextricably linked with the conduct of real scientific research and experimental design work.
4. **Innovation Principle:** Continuous updating of educational programs and scientific and technical base in accordance with advanced global trends (small modular reactors, fourth-generation reactors, closed fuel cycle).

5. **The Principle of Infrastructure Completeness:** Availability of our own modern scientific and experimental base, simulators and testing grounds.

1.4 Key Provisions for Structural Components

1.4. 1. Educational Program

- **Flexibility and Modularity:** Curricula must adapt to changing industry needs.
- **Practice-oriented:** A significant portion of time is devoted to laboratory work, internships at operating facilities and work on simulators.
- **Fundamental Base:** Study of reactor physics, thermal hydraulics, safety systems, materials science, spent nuclear fuel and radioactive waste management.

1.4. 2. Infrastructure and Experimental Base

- **Modernity and Safety:** Creation of laboratories equipped with modern equipment that meets all radiation and nuclear safety requirements.
- **Multifunctionality:** Possibility of conducting research in various areas of nuclear engineering.
- **Use of digital twins:** Widespread use of computer modeling and virtual simulators.

1.4. 3. Human Resources Potential

- **High Qualification:** Attracting leading scientists and industry experts to teaching and scientific supervision.
- **Continuous Training:** Availability of a system of advanced training for Module employees and industry specialists.

1.4. 4. Research Program

- **Strategic Directions:** Identification of priority research areas consistent with national energy plans.
- **Industrial Partnership:** Conducting research commissioned by industrial enterprises.

1.5. Stages of Development and Implementation

The development of the Module is carried out in stages:

1. **Conceptualization:** Needs analysis, strategy development, team building and conceptual design.
2. **Institutionalization:** Creation of a legal structure, accreditation of programs, formation of a material base and preparation of infrastructure.
3. **Launch and Development:** Commencement of training and research, expansion of infrastructure and scientific and educational programs.
4. **Sustainable Operations:** Achieving stable personnel reproduction, conducting advanced research, scaling up experience and international integration.

1.6. Mechanisms for Implementation and Ensuring Long-Term Sustainability

- **State support:** The module is considered as a strategic state project.
- **Diversification of funding:** Attracting funds from government programs, grants from scientific foundations, and business contracts with industry.
- **Risk Management:** Continuous monitoring and management of technological, financial, human resources and geopolitical risks.
- **Integration into the international space:** Development of academic mobility, participation in international research consortia while strictly adhering to the non-proliferation regime.

1.7. Expected Effects of Module Implementation

- **Ensuring energy security** through our own competencies.
- **Increasing the scientific and technical prestige** of the state in the international arena.
- **Development of related high-tech sectors** of the economy.
- **Formation of a new generation of scientific and technical elite.**

1.8. Platform for creation

The creation of a specialized scientific and educational module on nuclear engineering is planned at the University of Belgrade (Univerzitet u Beogradu)

Foundation and Basics: The university is viewed as the fundamental resource upon which the entire module is built. This entails utilizing the university's existing deep expertise, research schools, human resources, and accumulated knowledge. The module is built *on* the university's strengths.

Resources and Competencies: The University is the main source of human, intellectual and material resources for development and teaching.

The created module becomes an integral, organic part of the university's existing educational programs and research areas.

The University of Belgrade has **31 faculties** covering a wide range of disciplines. Creating a specialized module in nuclear engineering is a complex, multidisciplinary undertaking requiring the involvement of key faculties and departments. The active participation of the following faculties is recommended:

- **Machine Faculty (Machinsky fakultet)** : Departments related to thermal power engineering, mechanics, materials, and automatic control systems.
- **Faculty of Electrical Engineering (Electrotechnical Faculty)** : Departments of Power Engineering, Electronics, Automation, and Information Technology.
- **Faculty of Technology and Metallurgy (Faculty of Technology and Metallurgy)** : Departments of Chemical Engineering, Metallurgy, and Materials Science.



- **Faculty of Civil Engineering (Građevinski fakultet)** : Critical for modules on construction management, site preparation engineering, geotechnics, and structural analysis.
- **Faculty of Physics (Physics Faculty)** : Departments of Nuclear Physics, Theoretical Physics.
- **Chemical Faculty**: Departments of Radiochemistry, Inorganic Chemistry.
- **Faculty of Organizational Sciences (Faculty of Organizational Science)** : Departments of Project Management, Quality (QA/QC), Operations Management, Logistics.

Engaging third-party organizations is also crucial to ensure practical relevance, regulatory compliance, and the use of unique expertise. In Serbia, it is recommended to engage the following third-party organizations:

- **Директорат по радиационној и нуклеарној безбедности Србије - СРБАТОМ**) : The key regulatory body whose participation is necessary for the integration of safety requirements, licensing and safety culture into the program.
- **Institute of Nuclear Sciences "Vinča" (Institut za nuclearne nauke „Vinča“)** : Historically, Serbia's main scientific centre in the field of nuclear technology, with unique expertise, laboratory facilities and infrastructure that can be used for teaching and research.
- **Ministry of Mines and Energy** : To ensure that the programme is consistent with the state energy strategy and the needs of the industry.
- **Ministry of Science, Technological Development and Innovation** : To support the research component of the programme, particularly at the doctoral level.
- **Specialized engineering and construction companies** : Engaging industry experts with experience implementing large and complex projects for practical training, case study development, and internships.
- Looking ahead: **International partners and vendors** : Collaboration with foreign universities, research centers, and nuclear technology suppliers to share experiences, access simulators, and organize international internships.

1.9. Education system

At the University of Belgrade, like many European universities, the education system is structured according to the principles of the Bologna Process. There are three main levels of academic education:

1. **Basic Academic Studies (Basic Academic Studies)**: This is the first stage of higher education, equivalent to a **bachelor's degree** . Studies typically last 3-4 years and require 180-240 ECTS (European Credit Transfer System) credits.
2. **Master's Academic Studies (Master's Academic Studies)**: This is the second level of education, equivalent to a **master's degree** . Studies typically last 1-2 years (60-120 ECTS credits) after completing undergraduate studies. A total of 300 ECTS credits (including bachelor's degree credits) are required to obtain a master's degree.



3. **Doctoral Academic Studies (Doktorske akademske studije):** This is the highest level of education, equivalent to a PhD degree. The study lasts three years (180 ECTS credits) after completing a master's degree.

In addition to these academic programs, there are also specialized academic studies (specializations) and applied research at various levels, but the three above represent the main stages of academic growth. In some fields (for example, medicine), there are integrated academic programs that combine undergraduate and master's studies into a single, continuous cycle.

The university, like most European universities, adheres to **the Bologna process and the ECTS** (European Credit Transfer and Accumulation System). This means that the educational structure must be clear, hierarchical, and understandable within an international framework.

The structure and hierarchy of terms (Level of Education, Programme, Study Unit, Module, Task Unit) presented below in Section 3 are fully **consistent with the academic structure adopted in Belgrade**.

It is important to understand that terminology and specific divisions of master's programs may vary across different educational systems.

The educational program "Nuclear Engineering" can be structured as a comprehensive multi-stage curriculum covering three cycles of higher education:

1. **The fundamental cycle**, corresponding to the first stage of higher education (typically a bachelor's degree), aims to develop a solid foundation in the fundamental sciences, basic engineering principles and introductory concepts of nuclear engineering.
2. This is followed by a **specialised Master's degree** (which may include various specialisations or lead to advanced degrees such as a Master of Science (MSc) with a focus on nuclear energy, a Master in Nuclear Energy or a Master in Nuclear Engineering), covering advanced academic subjects, specialised projects and deepening expertise in chosen areas.
3. **The final research phase of doctoral studies** leading to the Doctor of Philosophy (PhD) degree is dedicated to conducting significant original research and making a contribution to knowledge in the discipline of nuclear engineering.

The Educational Programme "Nuclear Engineering" is a complex multi-stage system of personnel training, implemented at three successive Levels of Education: Basic Academic Studies (Osnovne akademske studije), Master's Academic Studies (Master akademske studije) and Doctoral Academic Studies (Doktorske akademske studije).

The structure of the Program consists of Specialized Modules at all Levels, each of which is based on the integration of specialized Training Blocks (Fundamental, Engineering, Management, etc.), each of which consists of a set of autonomous, assessed Training Courses.

Below is a table aligned with the official academic terminology of the Bologna Process, ECTS (European Credit Transfer System) and the practice of the University of Belgrade.



Hierarchy level (Belgrade / ECTS)	Terminology from the document	What should this be called officially?	Comment on the attachment
Higher (Institutional)	—	University / Faculty	The entire University of Belgrade or a separate Faculty (as the highest administrative body).
2 (Unit/Field)	Nuclear engineering (out of context)	Department / Academic Field	A large academic unit (or Department of Studies) responsible for delivering a number of programs in a single field of study.
3 (Program)	"Specialized Module" (from the document) / Program (Master's/Doctoral)	Educational Program (<i>Degree Program / Study Program</i>)	A comprehensive, accredited program leading to a degree (e.g., MSc in Nuclear Engineering). <i>We are currently developing its content.</i>
4 (Subject Section / Area)	"Block" (Fundamental, Technological, etc.)	Block / Course Area	A large section within the program, combining several courses/disciplines on a single topic (for example, the Nuclear Construction Management Unit). Six units were standardized.
5 (Autonomous Educational Unit)	—	Course / Subject	An autonomous, assessed learning unit (component) within a Block. It has its own syllabus and ECTS credits. It includes lectures, seminars, and labs.
6 (Operating)	Task block	Task Block / Project	A group of logically interconnected practical, computational, or research assignments <i>within a single module/course</i> . Aimed at skill development.
7 (Pedagogical element)	Task / Assignment	Task / Assignment / Exercise	A basic task for a student (pile calculation, seam drawing, answer to a test question).

SECTION 2. PROBLEM FORMULATION

Current discussions are focused on the creation of a **specialized module specifically at the master's and doctoral levels** , combining the efforts of several faculties and research institutes.

This is because the most pragmatic approach to reviving nuclear energy in Serbia is to leverage the existing strong engineering and scientific infrastructure for the in-depth training of highly qualified specialists. The involvement of various faculties (Mechanical Engineering, Electrical Engineering, Technology, Physics, etc.) allows for the accumulation of existing experience and

infrastructure for conducting specialized courses and research at the master's and doctoral levels.

Creating a *full-fledged educational program* starting with the undergraduate level (Osnovne akademske studije) would require significantly more resources, developing fundamental courses from scratch, and guaranteeing a stable enrollment of students interested in nuclear engineering at an early stage. Therefore, an initial focus on postgraduate education appears to be a more rapid and effective step.

2.1. Specialized and non-specialized education. Compatibility.

In today's dynamic world, higher education pathways are becoming increasingly flexible and diverse. The traditional notion of a rigid sequence of specialized training at all levels is gradually giving way to an interdisciplinary approach and recognition of the value of diverse competencies. In this chapter, we will examine one of the most pressing and debated questions in the context of higher education: can someone who has completed a non-core foundational education at the Basic Academic Studies (Osnovne akademske studije) level not only successfully complete specialized training at the Master's (MSc) level but also achieve a research-based doctorate (PhD)?

We will analyze the factors that determine the compatibility of various educational pathways, the role of equalization programs, and the unique advantages and challenges that a non-major background can bring to cutting-edge scientific and engineering research. Is a non-major start truly an obstacle, or does it open the door to innovative solutions at the intersection of disciplines?

The success of a student with a non-core basic education (*Osnovne akademske studije*) at the specialized master's (*MSc*) and doctoral (*PhD*) levels is a **very real and common scenario** , although it is associated with certain challenges.

The hypothesis that non-core education is a "weakness" is only partially true. In modern interdisciplinary sciences like nuclear engineering, diverse backgrounds often become a competitive advantage.

The success of such a learning path —from bachelor's to doctoral—depends not on the fact of being “non-core,” but on a set of critically important conditions.

2.1. 1. Availability of Knowledge Alignment Programs (Bridge Programs)

This is the most common and effective mechanism. Universities often offer (or even require) students with non-major backgrounds to take a series of intensive courses to fill gaps in their fundamental knowledge.

Example for nuclear engineering: If your undergraduate degree was in chemistry, you will likely be offered courses in thermal physics and neutron transport to bring you up to par with mechanical engineering or physics graduates.

2.1 . 2. Understanding Interdisciplinary Synergies and Backgrounds

Nuclear energy is more than just reactor physics. It's a complex system. A student with a non-nuclear background can bring unique competencies unavailable to a traditional nuclear engineer.

- **Bachelor of Science in Chemistry:** Will more easily master modules on **radiochemistry, fuel cycle and spent nuclear fuel reprocessing** .
- **Bachelor of Science in Materials Science:** Will become an expert in **nuclear reactor materials and behavior under radiation** .
- **Bachelor of Civil Engineering:** Will be indispensable in the specialized module on **engineering site preparation and construction management** .

2.1. 3. Systems engineering and vendor independence

As we discussed earlier, modern nuclear education (especially the Chinese model, see Section 3) emphasizes a systems approach and fundamental principles, rather than the operation of a single design. This means that **the ability to think abstractly and model** is often more important than knowledge of the specific procedures of a particular reactor. A student with a strong mathematical foundation and programming skills can master universal multiphysics simulators more quickly than an experienced operator.

2.1. 4. Motivation and research focus (PhD level)

At the doctoral level (*PhD*), the key factor for success is not what you *already know* , but how well you can *generate new knowledge* . A student with a non-core background may focus their research on interdisciplinary topics.

An example of research at the intersection: Development of new composite materials for SMRs (at the intersection of materials science and nuclear engineering) or the use of AI to optimize supply chains in nuclear construction (at the intersection of logistics and Construction Management).

2.1.5. Conclusion

Thus, a student with a non-core *Osnovne akademske studije education* can be extremely successful at the *MSc* and *PhD* levels if:

- The university offers effective **bridge programs** to level up knowledge.
- The training is based on **vendor-independent fundamental principles** and multi-platform technology analysis.
- A specialization (such as Construction Management or Materials Science) allows a student to utilize their **unique interdisciplinary background** .

For our work on the module concept in Serbia, this means we need to build into the structure **a clear mechanism for entrance testing and mandatory compensatory modules** for students with non-major backgrounds. This will not only ensure the program remains strong but will also expand the talent pool by attracting talented engineers and scientists from related fields.

SECTION 3. ANALYSIS OF THE EXPERIENCE OF FOREIGN COUNTRIES

Considering that Serbia is developing nuclear energy from scratch, **the Nuclear Engineering Program in general and the Specialized Scientific and Educational Module in Nuclear**

Engineering in particular, it should be a strategic tool for training personnel capable of ensuring the country's technological flexibility and independence.

Therefore, the Module must combine three fundamental approaches:

1. **The French model:** Highly detailed PWR/EPR (pressurized water reactor) technologies, strict safety standards, and a thorough understanding of the fuel cycle and spent nuclear fuel/radioactive waste management. This provides the foundation for working with modern Western technologies.
2. **The Chinese model:** A vendor-independent fundamental base in the initial stages, a comparative analysis of a wide range of global technologies (PWR, VVER, CANDU, HTGR, SMR), and a focus on systems engineering and integration rather than the operation of a specific design. This will give Serbia flexibility in choosing a partner.
3. **Serbian Specifics:** Unique focus on **Nuclear Construction Management**, site preparation engineering and building a safety culture from day one.

The implementation of such a practice-oriented and multi-technological module will make the Belgrade program unique and in-demand, ensuring Serbia's readiness to implement its own nuclear projects in a multi-regulatory environment.

3.1. Review of existing programs

Nuclear Engineering Master's and Doctoral programs are a well-established and standardized educational track in countries with a developed nuclear industry or actively exporting nuclear technology.

Globally, these programs are divided into two schools: those focused on reactor physics and fundamental science, and those focused on applied engineering, materials science, and project management (which is closest to NUCON's profile).

Here are the world's leading programs of this level:

3.1. 1. Russia

The Russian school is distinguished by its close integration of universities with Rosatom enterprises, which allows students to gain practical experience at real facilities.

- **National Research Nuclear University MEPhI (Moscow):** The main anchor university of the Russian nuclear industry. It offers dozens of English- and Russian-language master's and doctoral programs (including for international students from countries where Rosatom is building nuclear power plants).
- **Peter the Great St. Petersburg Polytechnic University (SPbPU):** A strong foundation for the design and construction of energy facilities, including nuclear power plants.
- **Tomsk Polytechnic University (TPU):** Known for its programs in nuclear technology and research reactor operation.

3.1. 2. Europe

European programmes are often interdisciplinary and closely linked to EU regulations and projects of companies such as EDF.

- **France:** the National Institute of Nuclear Science and Technology (**INSTN**) of the Atomic Energy Commission (CEA), as well as **Paris-Saclay University** . France is a European leader in nuclear education, with programs covering the entire cycle: from design to decommissioning of nuclear power plants.
- **Czech Republic:** Czech Technical University (**ČVUT**) in Prague. It hosts the prestigious international ICONE conference, where Miloš Lazarević received an award. The university has an excellent master's degree program in nuclear engineering.
- **United Kingdom:** **The University of Manchester** and **Imperial College London** have strong PhD programs in nuclear materials and engineering.
- **Switzerland and Italy:** **ETH Zurich** and the Swiss **EPFL** offer joint master's programs. Interestingly, **the Technical University of Milan (Politecnico di Milano)** has one of the best nuclear engineering programs in Europe, despite Italy having decommissioned its nuclear power plants.

3.1. 2.1. Analysis of France's experience in nuclear education and training

The French Republic is a unique case for systemic analysis in the area of civil nuclear energy competence development. With one of the most scalable, vertically integrated, and sovereign nuclear industrial complexes in the world, France has consistently implemented a public policy based on nuclear generation for over half a century. A key factor in the success of the French nuclear program (the "Messmer Plan") has been the creation of a comprehensive, multi-level, and continuous system of professional education and training.

This system is characterized by unique parameters:

- **Strategic integration:** Close collaboration between government regulators (e.g. CEA), the academic community (leading engineering schools and universities) and industrial giants (EDF, Framatome, Orano) ensures that educational programs are precisely aligned with current and future industry needs.
- **Specialized infrastructure:** The presence of dedicated research and educational institutes, such as the National Institute of Nuclear Science and Technology (INSTN), which act as central hubs for training specialists and coordinating research.
- **A practice-oriented approach:** The extensive use of advanced simulators, training centers directly at nuclear fuel cycle facilities, and mandatory long-term internships in the industry develops in graduates not only deep theoretical knowledge but also a readiness to solve real-world engineering and management problems.

An analysis of the French nuclear training model is of exceptional value to states embarking on the development or scaling of national nuclear programs, as an example of a comprehensive and long-term approach to developing sustainable human resources, ensuring technological independence, and a safety culture in the nuclear industry.

The Memorandum of Understanding between the Government of the Republic of Serbia and Electricité de France (EDF) on establishing a framework for long-term dialogue and cooperation in the field of nuclear energy, signed in Paris on 8 April 2024, as well as subsequent statements by officials, place particular emphasis on training.

Below are **unofficial translations** of key provisions regarding education:

1. Direct collaboration in training:

- "...The memorandum lays the foundation for cooperation in the field of... **training and preparation of personnel** for the future Serbian nuclear program."

2. Support in developing competencies:

- "The French side (EDF) expresses its readiness to provide technical support and expertise for **the creation of educational and scientific research infrastructure** in Serbia."

3. Exchange and internships:

- "The parties will consider opportunities for **the exchange of students, postgraduate students, and young specialists** between Serbian and French academic and research institutions, as well as the organization **of internships at nuclear energy facilities** in France."

3.1. 2.2. French Master's program in Nuclear Energy (MNE)

France has a very strong nuclear industry and a well-developed education system in this field. Leading engineering schools and universities offer Master's programs (Master 2, equivalent to the fifth year of higher education), many of which are part of consortiums or offered jointly with the INSTN (National Institute of Nuclear Sciences and Technologies, part of the CEA – Alternative Energies and Atomic Energy Commission).

The Master in Nuclear Energy (MNE) program is offered by a consortium of several prestigious French educational institutions (including Université Paris-Saclay, INSTN, CentraleSupélec, Chimie ParisTech, École des Ponts ParisTech, and ENSTA Paris). This program is international and taught in English, but its structure is typical of French engineering training.

Below is a sample curriculum for one of the tracks in this master's program (Master 2, 2nd year of study) —**Nuclear Plant Design (NPD)** —with the number of hours (typically in-person classes, including lectures, seminars, and labs). Please note that the exact number of hours may vary slightly from year to year, but the information provided provides a realistic idea of the workload.

Curriculum for Master's Degree 2 "Nuclear Energy" (NPD track)

The training consists of two semesters: a semester of full-time classes (about 5-6 months) and a semester of diploma internship (5-6 months).

Semester 1 (Face-to-face classes)

The total number of full-time hours of classes in the first semester is **approximately 450-500 hours** .

Module/Course Name	Approximate number of hours	Description (briefly)
Core Courses	~180 hours	Fundamental disciplines for all students.
- Nuclear physics	~30 h.	Fundamentals of interaction of radiation with matter, fission reactions.
- Thermal physics and hydraulics of reactors	~40 h.	Heat transfer, boiling, two-phase flows in the active zone.



Module/Course Name	Approximate number of hours	Description (briefly)
- Neutron physics	~40 h.	Neutron transport equation, reactor kinetics.
- Nuclear reactor materials	~30 h.	Behavior of materials under irradiation, corrosion.
- Fuel cycle and safety	~40 h.	Spent nuclear fuel reprocessing, nuclear power plant safety principles.
Specialized module (NPD Focus)	~220 hours	Advanced courses in design and engineering.
- Design of reactor systems (PWR/EPR)	~50 h.	Design of the housing, PG, MCP, safety systems.
- Structural engineering and seismic resistance	~40 h.	Calculations of buildings, structures, seismic analysis.
- Codes and standards (RCC-M, RCC-E...)	~30 h.	French equipment design standards.
- Project management and economics	~30 h.	Estimates, construction schedules, economic aspects.
- Nuclear instrumentation and control	~30 h.	Sensors, automation systems, control panel.
- Systems integration and layout	~40 h.	Equipment placement, pipeline routing.
Additional courses and projects	~70-100 hours	
- Design Project	~40-60 h.	Teamwork on a real engineering problem.
- Foreign language (French/English)	~20-30 h.	
- Seminars on safety culture	~10-15 h.	

Semester 2 (Internship)

Event	Duration	Description
Diploma internship (Master Thesis / Internship)	5-6 months (min. 20 weeks)	A paid internship in industry (EDF, Framatome, Orano, etc.) or a research center (CEA, CNRS) focused on a specific engineering or research task. It culminates in the writing and defense of a thesis. Work hours correspond to a standard intern's workweek in France (usually 35-39 hours per week, resulting in ~700-900+ working hours over the entire period).

Important notes:

- **ECTS:** In France and Europe, study time is measured not only in hours but also in ECTS (European Credit Transfer and Accumulation System) credits. One year of a Master's degree equals 60 ECTS credits. Approximately, 1 ECTS corresponds to 25-30 hours of a student's total workload (including in-person classes, independent study, exam preparation, and project work). Face-to-face teaching typically accounts for a smaller portion of this total workload (often 10-15 hours per ECTS credit). The hours listed above for Semester 1 are in-person hours.
- **Class types:** In-person hours are divided into lectures (CM - Cours Magistraux), practical classes (TD - Travaux Dirigés), and laboratory/practical work (TP - Travaux Pratiques). Projects often include a significant amount of independent or teamwork, which is not always included in the in-person "teaching" hours.
- **References:** Information on specific hours is best found in the detailed course syllabuses on the official university websites or in their brochures. We also used generalized data typical for this program and INSTN, which is a key player in many such master's programs.

3.1.3. Asia

Asian universities are currently demonstrating the fastest growth in the quality of nuclear education due to the massive construction of new power units.

- **South Korea:** Korea Advanced Institute of Science and Technology (**KAIST**) and **Seoul National University** . Korean programs are highly pragmatic and focused on the export of their technologies (for example, APR-1400 reactors) and rapid, efficient construction.
- **China:** **Tsinghua** University and **Xi'an Jiaotong University** . Enormous government investment makes these doctoral schools among the most technologically advanced in the world.

3.1.3. 1. Analysis of the Chinese experience

Analyzing China's experience in training nuclear engineering personnel is extremely valuable, as China has evolved over the past decades from technology procurement to the creation of its own sovereign designs (such as Hualong One), while maintaining expertise in operating Western and Russian reactors. This inevitably impacts their educational model.

Your assumption is confirmed: the programs of leading Chinese universities, such as Tsinghua University, Xi'an Jiaotong University, or Harbin Engineering University, are indeed **more vendor-independent and fundamental in nature** at the level of basic engineering training. Let's analyze what exactly makes their programs special and what useful lessons we can learn from them when creating your module.

3.1.3.2. Analysis of Chinese Universities' Programs (Trends and Structure)

1. Focus on Fundamental Principles, Not Reactor Specifics:

Instead of learning how to operate a single vendor's "Type A Reactor," Chinese students study **the physics and thermal hydraulics of reactor systems as such** .

- **Example:** The course "Nuclear Reactor Physics" examines kinetic equations, neutron balance, and feedbacks applicable to any light-water reactor (PWR/BWR), as well as gas-cooled reactors (HTGR) and fast breeder reactors (FBR). Vendor-specific issues are introduced later as a special application of these principles.

2. Study of Multiple Reactor Types (Diversity of Technologies):

China is the only country where reactors of various types and designs are simultaneously operated and built: PWR (Chinese CNP, HPR; French EPR; American AP1000), VVER (Russian), CANDU (Canadian PHWR), HTGR (high-temperature gas-cooled) and FBR (fast sodium).

- **Useful experience:** The curriculum includes an overview *of all* these technologies, giving engineers a broad understanding of various engineering solutions, safety systems, and fuel cycle approaches. This makes them prepared to work with *any* technology the government may choose in the future.

3. Integration of Theory and Multi-Physical Simulation (Digital Twins):

Chinese universities were among the first to integrate the concept of digital twins and multiphysics modeling into the educational process. Students don't just memorize formulas; they use specialized software (e.g., system-level simulators, CFD codes) to model transient processes in *any* type of reactor.

- **Useful experience:** This allows for "simulation training" without being tied to a specific vendor's hardware. Students can change core parameters and see how this impacts the safety of a PWR or HTGR.

4. Training Integration Engineers, not "Button Operators":

The goal of the Chinese program is to train an engineer who can design a system or manage a complex project, not just an operator who follows one vendor's procedures.

- **Useful experience:** The emphasis is on systems engineering, risk management, safety culture, and understanding the entire NPP lifecycle. This develops critical thinking and adaptability.

China, as a country operating a "technological mosaic" fleet of nuclear power plants, has created a unique educational model aimed at training specialists capable of working with *any* type of reactor.

3.1.3.3 . Programs of Chinese universities

We analyzed the curricula and program structure of Nuclear Science and Technology (NST) at several leading universities in China.

- **Tsinghua University:** This is the undisputed leader in nuclear education in China. It has a specialized Institute of Nuclear and New Energy Technology (INET). Their programs (undergraduate, graduate, and PhD) focus on:
 - **Fundamental Theory:** In-depth study of neutron physics, reactor thermal physics, and nuclear materials science applicable to a wide range of systems.
 - **Technological diversity:** Study of the operating principles and safety of PWR, BWR, CANDU, VVER, as well as China's own developments (Hualong One, HTGR - high-temperature gas-cooled reactors).
 - **Multiphysics Simulation:** Students learn to use advanced simulation codes to simulate various reactor processes without being tied to a specific vendor.
- **Xi'an Jiaotong University (XJTU):** XJTU's School of Nuclear Science and Technology is renowned for its strong engineering foundation. Programs emphasize:
 - **Systems Engineering:** Understanding the NPP as a complex system of systems, where principles of integration and safety are primary to the details of a single design.
 - **Operator Training:** XJTU trains specialists who can quickly adapt to various control rooms (CB) thanks to a deep understanding of fundamental processes.
- **Harbin Engineering University (HEU):** HEU's College of Nuclear Science and Technology. Their programs have historically been strong in the field of marine nuclear installations, which requires a high level of abstraction. They focus on:
 - **Control and Security Theories:** A study of the general principles of automatic control and defense in depth applicable to a variety of designs.

3.1.3.4. What can we learn for the Module in Serbia?

To develop a specialized nuclear engineering module in Serbia, China's experience allows us to formulate the following principles, which differ from those of vendor-based programs:

- **Systems Approach and Security:** Training should focus on the general principles of defense in depth, passive security systems and security culture applicable to any technology
- **The fundamental foundation must be vendor-neutral:** The first stage of training should be devoted exclusively to nuclear physics, neutron transport, thermal hydraulics, and materials science, without reference to specific vendors. This will create a "universal language" and a deep understanding of the principles.
- **Technological multi-platform:** The module should include an overview and comparative analysis of key global reactor technologies (PWR, VVER, HTGR, SMR). This will give Serbia flexibility: specialists trained under this program will be able to work with *any* partner the country chooses in the future.
- **Investing in generic (non-vendor) simulators:** Instead of purchasing expensive vendor-specific simulators, focus on building a powerful base of universal simulators and multiphysics codes. This will allow you to "train on models" of various systems without being tied to hardware from a single vendor. This is less expensive and provides better competencies.
- **Developing Integration Engineers, Not "Button Operators":** The goal of this module is to prepare an engineer who can design a system or manage a complex project, not just an operator following a single vendor's procedures.

3.1.4. USA

The American system is based on powerful research laboratories and grants from the Department of Energy.

- **MIT (Massachusetts Institute of Technology):** Traditionally ranks among the top universities in the world for nuclear engineering.
- **University of Michigan and Texas A&M University:** Offer some of the largest graduate and PhD programs, with active research into small modular reactors (SMRs) and microreactors.

Summary for our situation: When forming its module, the University of Belgrade will most likely take as a basis the curricula of European (Czech, French) or Russian partner universities.

The traditional weakness of most of these classic academic programs is **construction management and engineering preparation of complex sites**. Graduates are well-versed in reactor physics, but lack the knowledge to organize the pouring of a "nuclear island" or build a QA/QC system for contractors. It is precisely this gap in academic programs that NUCON and I can offer to address in Belgrade.

Since Serbia is currently in the partner selection phase and is in dialogue with three key players at once – France (EDF), Russia (Rosatom), and South Korea (KHNP) – the ideal course for the University of Belgrade should be “vendor-independent.”

Given the long-term development and implementation cycles of educational programs for the nuclear industry, the concept of technological indifference (vendor independence) may seem of limited relevance at the start of training, as by this time the strategic decision to select the

primary technology supplier has already been made. However, implementing a program that is independent of specific vendor specifications is critical to ensuring the professional mobility and long-term competitiveness of graduates in the international labor market, including their integration into projects implemented in the European Union.

An additional factor necessitating this approach is the global nature of nuclear power plant construction, which is typically carried out by international consortia using multi-vector supply chains from various countries and regions. Consequently, developing students' deep competencies in navigating and operating within a multi-regulatory environment (including various national and international safety, design, and operational standards) is fundamental to the successful implementation of nuclear energy projects.

The analyzed documents contain references to scientific and educational programs implemented in the home countries of various nuclear technology vendors. It was found that these programs are generally oriented toward the technological standards and specifications adopted in their host countries. Meanwhile, the People's Republic of China, due to historical and economic factors, operates a wide range of nuclear power plants developed by vendors from various countries (Russia, France, the United States, and Canada), while simultaneously developing its own projects.

Based on this, it is hypothesized that curricula at leading Chinese higher education institutions may have a higher degree of vendor independence, focusing on fundamental principles of nuclear engineering and cross-platform technology analysis, as opposed to programs that are tightly tied to a specific technology design of a single vendor.

SECTION 4. BUILDING THE SYSTEM IN SERBIA

4.1. Structure and hierarchy of terms

This is a fundamental issue for building any systemic educational program. Adopting a unified terminology is key to success, especially when development and implementation can span several years.

Let's look at the issues sequentially and create a coherent, academically sound structure.

4.1. 1. Terminology: Master's and Doctoral studies

"Master's degree" and "Doctoral degree" are perfectly valid academic terms. In scientific and educational circles, they are classified as follows:

Acceptable term	What is the focus?	When to use
Level of Education <i>(Educational Level)</i>	On the hierarchy in the higher education system (Level of higher education).	This is the most precise and official scientific term.
Stage of Training <i>(Stage of Study)</i>	On the sequence and completion of one stage before the beginning of another.	Suitable for describing a student's trajectory.

Educational Program (Degree Program)	On the content, objectives and learning outcomes leading to the degree.	When the curriculum itself is discussed.
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4.1. 2. Unified structure: Block, Module, Task

Systems engineering and instructional design have a clear hierarchy. To avoid confusion when different things are called "blocks," we will establish strict nesting and consistent naming.

The principle of investment:

Program -> Levels -> **Study Blocks** -> Modules -> **Task Blocks** -> Individual Tasks

Unified structure and hierarchy:

We are standardizing the names of the Large Blocks (thematic sections of the program) so that they are unified.

Hierarchy level (from large to small)	Accepted term (Unified name)	What is it and what is included?
1 (Highest)	Educational Program (Program)	A full range of training in a specialty (for example, "Nuclear Engineering").
2	Level of Education (Educational Level)	Master's / Doctoral degree.
3	Training Block (Curricular Block)	A large, complete thematic section of the program. <i>This is where we introduce unified functional names.</i>
4	Module (Module)	An autonomous academic unit within a Block, dedicated to a specific, narrow topic (course, semester). It has clear objectives and assessment methods.
5 (Operating)	Task Block (Task Block)	A group of logically interconnected practical, laboratory, or computational problems <i>within a single module</i> . Aimed at developing a specific skill.
6 (Small)	Task/Exercise (Task / Exercise)	An elementary task for a student (calculation, test, drawing).

4.1. 3. Uniform names of educational blocks (Level 3)

To avoid confusion and standardize the structure, we propose using the following functional names for thematic Study Blocks (large sections of the program):

- Fundamental block** (Foundational Block): Includes a vendor-independent base (nuclear physics, thermal hydraulics, materials science). *Chinese model.*

2. **Comparative analysis of technologies** (*Technology Analysis Block*): Study and comparison of various reactor technologies (PWR, VVER, SMR). *Chinese model*.
3. **Technological block (Vendor specific)** (*Technology-Specific Block*): In-depth study of a specific partner's technology. *French model*.
4. **Modeling and Simulation Unit** (*Modeling & Simulation Block*): Using universal and multiphysics simulators.
5. **Engineering block** (*Engineering & Infrastructure Block*): Includes site preparation engineering, nuclear island, and **welding technology and weld quality control** .
6. **Management Block** : Includes **Nuclear Construction Management** , QA/QC, logistics, economics and safety culture.

4.1.4. Example: Nesting in a hierarchy

Let's use a specific example from your specialty to show how this structure works:

- **Educational Program:** Nuclear Engineering (Serbia)
 - **Level of Education:** Master's degree (MSc)
 - **Curriculum Block (Level 3):** Engineering Block
 - **Module (Level 4):** Site Engineering
 - **Task Block (Level 5):** Calculation of seismic resistance of the foundation
 - **Task (Level 6):** Calculation of dynamic load on pile No. 5.

Educational Program Nuclear Engineering consists of the **Basics educational block** at the first stage and higher education corresponding to a **bachelor's** degree , **Master's program in Nuclear Energy / Engineering** , Master's degree program (Master of Science - MSc) and Doctoral degree program (Doctor of Philosophy - PhD)

Given that in our analysis we considered both highly detailed French programs (with hours specified) and more fundamental vendor-neutral approaches (e.g. Chinese), we can provide you with a **detailed example of a syllabus for a Master in Nuclear Energy / Engineering program** .

This example is based on the structure and volume of full-time classes of typical European (particularly French) and international second-year Master's programs (Master 2, corresponding to the fifth year of higher education), which are often offered by consortia of universities and research centers. This syllabus is suitable for training highly qualified design engineers, researchers, and managers.

Please note that specific courses, their titles, and the exact schedule of hours may vary from institution to institution. The information provided is **approximate** , but reflects the structure and workload for this level of preparation.

As a rule, **the Educational Program** precedes **the Syllabus** , which is developed on its basis.

4.2. Sample Educational Programs and Syllabus for the Nuclear Energy Program

Given below The syllabus and curriculum provide a detailed example of how high-level nuclear engineering education can be structured. The hour counts for each course and module are *approximate estimates* , reflecting the significant classroom workload required per semester to achieve a high level of competency.

As discussed earlier, this framework can be adapted to create a specialized module in Serbia by laying down a vendor-independent foundation in the initial stages, implementing comparative analysis of technologies (including SMR), and using universal simulators to ensure the country's technological flexibility.

Transforming a program from an “operator” (tied to a specific supplier) to an “engineering system” requires rethinking each component.

To achieve this goal, we must follow the following key principles when adapting the structure:

1. **Fundamentals as an absolute priority:** In the early stages of training, it is necessary to focus exclusively on the fundamental physical principles of nuclear fission, neutron transport, thermohydraulics, and materials science, applicable to a wide range of systems, without being tied to specific brands.
2. **Technological multi-platform:** The module should include a systematic review and comparative analysis of key global reactor technologies (PWR, VVER, HTGR, SMR) to enable specialists to understand the various engineering solutions, safety systems, and fuel cycle approaches.
3. **Universal Simulation:** Practical training should be based not on vendor-specific simulators, but on the use of universal system-level simulators and cross-platform multiphysics modeling software. This will teach students to simulate processes in *any* reactor.

Classic academic nuclear engineering programs typically focus on fundamental disciplines: nuclear physics, neutron transport, thermal physics, reactor safety, and the fuel cycle. This provides graduates with a strong theoretical foundation, but leaves a gap in the practical competencies required for actual nuclear power plant construction.

Nuclear Construction Management and Site Engineering in the Belgrade program is a strategically important decision. This will enable the training of specialists capable of not only designing reactors but also implementing these projects in the physical form, which is critical for the successful development of nuclear energy.

The implementation of such a practice-oriented module will make the Belgrade program unique and in demand on the international market, ensuring Serbia's technological independence and readiness to implement its own nuclear projects.

The programs and syllabuses are developed based on the principles of vendor independence, multi-platform technology (including small modular reactors), and the use of universal multiphysics simulation simulators. The training is divided into a general educational

foundation, specialized training at the master's (MSc) level, and research-based doctoral (PhD) level.

To eliminate misunderstandings between the concepts of "curriculum" and "syllabus," and to clearly structure instruction at all three levels of education at the University of Belgrade, we have developed a comprehensive document structure.

Our concept is based on a clear, scientifically based distinction:

1. **Degree Program:** This is a global framework document defining the goals and learning outcomes for the entire period (several years) leading to the completion of an academic degree (e.g., a Master's degree in Nuclear Engineering). It is a contract between the university and the state/society.
2. **Syllabus:** This is a detailed guide for a student on **a specific academic subject/course** within a given program. It is a contract between the instructor and the student. The syllabus is always derived and developed based on the Educational Program.

4.2.1. Detailed structure and expanded content of documents

Below is a detailed description of the structure of each of the three blocks, clearly distinguishing between the "Educational Programme" and the "Syllabus" at each level of education, taking into account Serbian specifics and ECTS (European Credit Transfer System).

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Part I: Basic Academic Research (*Osnovne akademske studije*)

At this level, the focus is on developing fundamental knowledge and core engineering competencies. The program is more structured, and the syllabi are more prescriptive, with clearly defined topics and tests.

Document type	Key Sections and Extended Contents	Description and Focus
Educational Program (Osnovne akademske studije)	<p>1. Learning Objectives and Outcomes:</p> <ul style="list-style-type: none"> * Formation of a solid fundamental base in the fields of mathematics, physics and chemistry. * Provide an understanding of the basic principles of nuclear engineering, safety and non-proliferation. * Development of critical thinking, communication and teamwork skills. <p>2. Structure of the Programme and ECTS:</p> <ul style="list-style-type: none"> * Total volume: 180-240 ECTS credits (3-4 years). * Study Blocks (Thematic): Fundamental Block (Nuclear Physics, Thermohydraulics, Materials Science) – 60% ECTS; Engineering Block – 20% ECTS; Comparative Analysis Block (Introduction) – 10% ECTS; Management and Safety Culture – 10% ECTS. * Diploma thesis/Project: (15-30 ECTS). <p>3. Evaluation System and Quality Assurance:</p> <ul style="list-style-type: none"> * Criteria for assessing the achievement of learning outcomes for the entire program. * Program monitoring and updating procedures . 	<p>Focus: "What are we building?" and "Who are we training?" A global contract between the university and the state/society. The syllabus is developed <i>based on</i> the program.</p>
Syllabus (Discipline/Course Syllabus)	<p>1. Course Details: Title (e.g., "Fundamental Nuclear Physics"), Instructor, Contact Information.</p> <p>2. Learning Objectives and Outcomes (Specific):</p> <ul style="list-style-type: none"> * Understanding the fundamental laws of nuclear reactions and the interaction of radiation with matter. * Ability to perform basic neutron balance calculations for generalized systems. 	<p>Focus: On "How do we study this specific subject?" and "What should the student do?" A contract between the teacher and the student. A detailed plan for ONE subject.</p>

Document type	Key Sections and Extended Contents	Description and Focus
	<p>3. Schedule and Topics (Weekly):</p> <ul style="list-style-type: none"> * Week 1-2: Interaction of neutrons with matter. * Week 3-4: Nuclear division. Fission reactions. * Week 5-6: Neutron Cycle. * Week 7-8: Neutron Diffusion. Lab #1. * Week 9-10: Reactor Kinetics. Midterm Quiz #1. * Week 11-12: Defense in Depth and Passive Security Systems (Introduction). * Week 13-14: Comparative Analysis of Technologies (Introduction). <p>4. Evaluation System:</p> <ul style="list-style-type: none"> * Tests (30%), Lab Work (30%), Exam (40%). Clear scoring criteria. <p>5. Literature and Resources: Basic textbooks, required reading list.</p>	

Part II: Master's Academic Studies (Master akademske studije)

At this level, the focus shifts to specialized knowledge, engineering, systems approaches, and the training of systems engineers. The syllabi are more flexible, with an emphasis on projects, simulations, and internships.

Document type	Key Sections and Extended Contents	Description and Focus
Educational Program (Master akademske studije)	<p>1. Learning Objectives and Outcomes:</p> <ul style="list-style-type: none"> * Provide an in-depth, advanced understanding of specialized areas of nuclear engineering (e.g., core design, safety, construction management). * Development of systemic thinking and the ability to integrate interdisciplinary approaches. * Development of competencies in nuclear construction management, site preparation engineering, and safety culture. <p>2. Structure of the Programme and ECTS:</p> <ul style="list-style-type: none"> * Total: 60-120 ECTS credits (1-2 years) after Osnovne. 	<p>Focus: "What are we building?" and "Who are we training?" A global contract between the university and the state/society. The syllabus is developed <i>based on</i> the program.</p>

Document type	Key Sections and Extended Contents	Description and Focus
	<p>* Study Blocks (Thematic): Block of Comparative Analysis of Technologies (Advanced) – 20% ECTS; Block of Technology (Vendor Specifics) – 10% ECTS; Block of Modeling and Simulation – 20% ECTS; Block of Engineering – 30% ECTS; Block of Nuclear Construction Management – 20% ECTS.</p> <p>* Master's Thesis: (30 ECTS). Includes an internship in industry.</p> <p>3. Evaluation System and Quality Assurance:</p> <p>* Assessment of achievement of learning outcomes, including dissertation and internship.</p>	
<p>Syllabus (Discipline/Course Syllabus)</p>	<p>1. Course Details: Title (e.g. Construction Management), Instructor, Contact Information.</p> <p>2. Learning Objectives and Outcomes (Specific):</p> <ul style="list-style-type: none"> * Ability to plan highly complex projects using CPM/PERT. * Ability to develop and implement QA/QC procedures for contractors. * Understanding the logistics of unique equipment and temporary infrastructure. <p>3. Schedule and Topics (Weekly):</p> <ul style="list-style-type: none"> * Weeks 1-2: Specifics of Nuclear Construction. Project Planning. * Week 3-4: CPM/PERT. Resource and Time Management. * Week 5-6: Supply chain and logistics management for unique equipment. * Week 7-8: Welding technologies and quality control (QA/QC) of welded joints. * Week 9-10: Risk Management. Using BIM models. * Week 11-12: Digitalization of construction and digital twins. * Week 13-14: Nuclear Island Site Simulator. Project #1 Presentation. <p>4. Evaluation System:</p> <ul style="list-style-type: none"> * Project (60%), Presentations (20%), Dissertation (progress) (20%). Clear scoring criteria. 	<p>Focus: On "How do we study this specific subject?" and "What should the student do?" A contract between the teacher and the student. A detailed plan for ONE subject.</p>

Document type	Key Sections and Extended Contents	Description and Focus
	5. Literature and Resources: Basic textbooks, specialized modeling codes, simulators, required reading list.	

Part III: Doctoral Academic Research (Doktorske akademske studije)

At this level, the focus is on scientific research, innovation, and the training of research scientists capable of generating new knowledge. Studies include advanced courses (40% of the time) and a graduate internship/research (60% of the time). Syllabi are more flexible, with an emphasis on seminars, research, and publications.

Document type	Key Sections and Extended Contents	Description and Focus
Educational Program (Doktorske akademske studije)	<p>1. Learning Objectives and Outcomes:</p> <ul style="list-style-type: none"> * Provide an in-depth, advanced understanding of specialized areas of nuclear science and technology. * Developing the ability to conduct significant original research and make contributions to knowledge in the discipline. * Development of competencies in research management, innovation and academic communication. <p>2. Structure of the Programme and ECTS:</p> <ul style="list-style-type: none"> * Total: 180 ECTS credits (3 years) after Master. * Study Blocks (Thematic): Advanced courses and seminars – 40% ECTS; Graduation internship and research work – 60% ECTS. * PhD Thesis: (90 ECTS). <p>3. Evaluation System and Quality Assurance:</p> <ul style="list-style-type: none"> * Assessment of achievement of learning outcomes, including dissertations and publications. 	Focus: "What are we building?" and "Who are we training?" A global contract between the university and the state/society. The syllabus is developed <i>based on</i> the program.
Syllabus (Discipline/Course Syllabus)	<p>1. Course Details: Title (e.g., Advanced Neutron Transport Techniques), Instructor, Contact Information.</p> <p>2. Learning Objectives and Outcomes (Specific):</p>	Focus: On "How do we study this specific subject?" and "What should the student do?" A contract between

Document type	Key Sections and Extended Contents	Description and Focus
	<ul style="list-style-type: none"> * Understanding of advanced methods for solving the neutron transport equation. * Ability to develop and apply new algorithms for active zone modeling. 3. Schedule and Topics (Weekly): * Week 1-2: Advanced Neutron Transport Methods. Seminar #1. * Week 3-4: Transient Simulation. Workshop #2. * Week 5-6: Materials for Generation IV Reactors and SMRs. * Week 7-8: Managing in a Multinormative Space. Seminar #3. * Week 9-10: Innovative Nuclear Power Plant Construction Methods. Modular Construction. * Week 11-12: Robotic Welding Systems and Weld Control Using AI. * Week 13-14: Research. Presentation of results. 4. Evaluation System: * Publications (40%), Conference Participation (20%), Research Progress (40%). Clear scoring criteria. 5. Literature and Resources: Specialized modeling codes, simulators, required reading list. 	<p>the teacher and the student. A detailed plan for ONE subject.</p>

IN In the documents presented above, the main focus was on the structure of **academic coursework**, that is, the set of disciplines that form the theoretical basis.

The diploma internship and research project are not separate “blocks” in the same sense as “Nuclear Physics”, but they are mandatory, integral and, as a rule, the most significant components in terms of ECTS credits at postgraduate levels of education.

They permeate the program, acting as **an integrating factor** that translates theoretical knowledge into practical competencies and new scientific knowledge.

Below is a detailed description of how Internship and Research are taken into account at each of the three levels of education in accordance with the European ECTS standards.

4.2.2. Internship and Research in the Structure of Education Levels

1. Level: *Basic Academic Studies (Osnovne akademske studije / Bachelor)*

At this level, the internship and thesis serve as an initial introduction to the professional environment and the application of basic engineering principles.

- **Role:** Practical application of fundamentals, career guidance.
- **Accounting in the program:**
 - **Mandatory internship (Praksa):** Typically lasting 6–12 weeks after the third year or at the beginning of the fourth year (6–12 ECTS). Students complete this course at industrial facilities, design institutes, or regulatory bodies (e.g., SRBATOM).
 - **Bachelor's Thesis (Zavrshni Rad):** A short, independent project of an engineering or computational nature (usually 6–10 ECTS). The work is often based on practical experience.

2. Level: *Master's Academic Studies (Master akademske studije / Master)*

At the master's level, research and a specialized internship become the core of the second year of study, preparing the systems engineer.

- **Role:** Specialization, Applied Research, Engineering Design, Construction Management.
- **Accounting in the program:**
 - **Master's Thesis (Masterski rad):** This is the key component (usually **30 ECTS** out of 120, or up to 60 ECTS in purely research programs). The thesis is an independent piece of applied research or a complex engineering project.
 - **Graduation Internship (Internship):** Often a mandatory stage of dissertation preparation (3-6 months). It is conducted in industry (EDF, Orano, Framatome, Rosatom, Chinese corporations), engineering firms, or international research centers (CEA, CERN) on a specific engineering or research problem that forms the basis of the master's thesis. Internships in global international consortium settings, typical for nuclear power plant construction, ensure the development of the competencies necessary for successful employment on any European or

international project. This is where **Construction Management** competencies are developed .

3. Level: Doctoral academic research (Doktorske akademske studije / PhD)

At the doctoral level, original research and the creation of new knowledge are the main goals of the entire period of study.

- **Role:** Fundamental/breakthrough research, innovation, academic career, expert activity.
- **Accounting in the program:**
 - **Research Project and Doctoral Dissertation:** This is the core of the PhD (usually >60% of the total credit load, e.g., **120–150 ECTS** out of 180). All advanced courses and seminars are aimed at supporting this research project.
 - **Internships and mobility:** At the PhD level, internships are often voluntary and take the form of research stays of 3–12 months at partner institutes (e.g. CERN), foreign universities, or vendor R&D centers to use unique equipment, conduct joint experiments, or consult with global experts.

4.2.3. Summary table of the balance of teaching and research by level (ECTS)

This table demonstrates how, as the level of education increases, the focus shifts from classroom learning to independent research and practical work.

Level of education	ECTS standard	Share of academic blocks (Coursework)	Share of Diploma Internship and Research	Key Result (Output)
Bachelor's degree (Osnovne)	180–240 ECTS	~85–90%	~10–15%	Basic Practice + Diploma Project
Master's degree	60–120 ECTS	~50–70%	~30–50%	Specialized Internship + Master's Thesis (Engineer/Systems Engineer)
Doctoral studies (PhD)	180 ECTS	~30–40%	~60–70%	PhD Research + Doctoral Dissertation (Scientist/Innovator)

SECTION 5. IMPLEMENTATION STRATEGY AND DEVELOPMENT PROSPECTS

This section summarizes the conceptual development of the Nuclear Engineering Educational Program at the Master's (Master akademske studije) and Doctoral (Doktorske akademske studije) levels at the University of Belgrade and outlines a roadmap for future action. The implementation of this ambitious interdisciplinary initiative, which unites the efforts of the Faculty of Mechanical Engineering, the Faculty of Electrical Engineering, the Faculty of Technology, the Faculty of Physics, and the Faculty of Civil Engineering, as well as specialized research institutes (Vinča), requires precise planning and coordination.

5. 1. Approval of a Unified Structure and Terminology

To ensure transparency, academic compatibility within the Bologna Process and ECTS, and to eliminate misunderstandings between the Curriculum and the Syllabus, we adopt the following **unified hierarchy of academic documents** :

The Educational Program (*Degree Program / Study Program*), which is implemented at three consecutive **Levels of Education** (Basic, Master, Doctoral), is based on the integration of specialized **Curricular Blocks** (*Course Area*), each of which consists of a set of autonomous, assessed **Educational Modules/Courses** (*Course / Subject*).

5. 2. Expanded Structure of Learning Blocks and Syllabi

A key priority for future work is the detailed development of the content of the Curriculum Units, which form the basis of the Educational Program. We have developed an expanded structure and content for each of the three Educational Levels, clearly delineating the "Program" and "Syllabus," taking into account Serbian specifics, vendor independence, and a focus on construction management.

Examples of the implementation of this structure at the Master's and Doctoral levels:

- **For the Master's Level:** The "Nuclear Construction Management" Module/Course Syllabus will be detailed by week, covering topics from planning highly complex projects and QA/QC contractors to **welding technologies and weld quality control** , using the Nuclear Island site simulator. Assessment will be based on projects and presentations.
- **For the Doctoral Level:** The Advanced Seminar syllabus "Innovative Methods of Nuclear Power Plant Construction" will focus on research in robotic welding systems, **advanced welding methods (e.g., laser/hybrid welding, additive manufacturing for critical component welding)** , and AI-based welding control, as well as management in a multi-regulatory environment. Evaluation will include publications and conference participation.

5. 3. Key Areas of Further Work

In addition to the detailed development of Syllabi for all Modules/Courses within the six approved Curriculum Blocks (Fundamental, Technological, Modeling, Engineering and

Management), the successful implementation of the Program requires focus on the following areas:

5.3.1. Formalization of Cooperation and Attracting Partners:

- **Involvement of Faculties:** Conclusion of formal cooperation agreements between key faculties of the University of Belgrade (Mechanical Engineering, Electrical Engineering, Civil Engineering, etc.) for the joint implementation of the Program.
- **Third-Party Cooperation:** Developing sustainable partnerships with **the Serbian Directorate for Radiation and Nuclear Safety and Security (SRBATOM)** to integrate safety culture and compliance requirements, and with **the Vinča Institute of Nuclear Sciences** to leverage their unique expertise and laboratory facilities.

5.3.2. Industrial Integration and International Cooperation:

- **Vendor Engagement:** Establishing partnerships with international nuclear technology suppliers (EDF, Framatome, Orano, etc.), particularly given Serbia's current focus on France, to provide internships, access to simulators, and attract experts.
- **Core and Non-Core Education:** Implementing the hypothesis that non-core basic education is compatible with successful MSc and PhD studies. To this end, clear mechanisms for **entrance testing and mandatory bridge programs (leveling modules) will be incorporated into the structure of the Educational Programs** .

5.3.3. Accreditation and Quality of Education:

- **Accreditation Process:** Initiation of the formal accreditation process for new Master's and Doctoral programmes by the Commission for Accreditation and Quality Assurance (CAQA) of Serbia.
- **Quality Monitoring:** Development and implementation of an internal quality monitoring system for the Programme, including regular review of the Syllabi and assessment of the achievement of learning outcomes.

5.4. Plans for detailing the Concept

The document, in its current Version 1, represents a coherent and thoroughly developed concept. The transition from disparate ideas to a systemic document has been successfully accomplished. Its clear structure, logical nesting of levels and blocks, and integration of specific and strategic aspects make this document a powerful tool for further implementation.

Below are our detailed comments and plans for refinements and adjustments in subsequent versions 2 and above , organized by key areas:

5.4.1. Clarity of Hierarchy and Terminology (Program vs. Syllabus)

- **Positive aspect:** The document successfully implements the accepted unified hierarchy of documents and terms (Program -> Levels -> Study Units -> Modules -> Task Units -> Tasks). This eliminates previous misunderstandings and ensures academic compatibility. The clear distinction between the "Program" and the

"Syllabus" at all levels (undergraduate, graduate, and doctoral) is a fundamental advantage.

- **Note:** Although the structure is correctly nested, in some text descriptions of the Syllabuses (especially in the weekly examples), it is worth more **explicitly emphasizing the syllabus's derivation from the framework requirements of the Curriculum** . For example, when describing specific topics or tasks in the Syllabus, you can add the short phrase: " *developed in accordance with Curriculum Unit X and learning outcomes Y, defined by the Curriculum* ."
- **Improvement plans :** Add a **graphical diagram or document hierarchy chart** to the document structure section, showing how the Program objectives cascade into Learning Units and then into specific course syllabuses and objectives. **A syllabus template can also be added** , which instructors can use as a basis, clearly indicating the required fields (course details, objectives, ECTS, schedule, assessment, and references) and their relationship to the Program.

5.4. 2. Expansion and detailing of the content of Blocks

- **Positive aspect:** All six standardized learning units (Fundamental, Comparative Analysis, Technological, Modeling, Engineering, and Management) are presented and described. The detailed syllabi for specific modules (Construction Management, Welding) at the master's and PhD levels are excellent.
- **Note:** Some Syllabuses (e.g., for the Fundamental Unit in the undergraduate program) may be too general in their descriptions of topics. It's worth **striving for greater specificity in key concepts** , especially those that are important for further study (for example, when describing "neutron physics," the syllabus could specify the specific reaction types or calculation methods that will be covered).
- **Improvement plans :**
 - **Strengthen the description of the Multinormative Component:** Since this topic is highlighted as critical in the introduction and concept, it's worth **more explicitly outlining its integration into the Syllabi** of specific courses at all levels. For example, in the "Nuclear Construction Management" Syllabus for the Master's program, add specific topics on comparing safety standards across countries or licensing procedures. At the PhD level, add topics on harmonization of standards to the Seminar Syllabus.
 - **Specify the types of welding technologies:** In the Master's program syllabus in the Construction Management block, where welding technologies are mentioned, examples of specific welding methods whose qualifications will be studied (TIG, MMA, specific requirements for atomic welds) can be added. Similarly, at the PhD level, when describing innovations, more ambitious examples can be added (electron beam welding, additive technologies in welding). This will emphasize the technical depth of the program.
 - **Add examples of Task Blocks:** In the syllabuses of specific courses (especially in the master's program), you can add **examples of the implementation of Task Blocks** (level 6), demonstrating how a specific engineering or calculation

problem is derived from the course syllabus and syllabus. For example, for Construction Management, add an example of a Task Block for developing a QA/QC procedure for welding work for a specific contractor.

5.4. 3. Integration of Internships and Research

- **Positive aspect:** The summary table of the ECTS balance by level is very clear and useful.
- **Note:** Although the general ECTS allocation is prescribed, **greater attention should be paid to the content and assessment procedures** for internships and research. This is particularly important to ensure the quality and relevance of these components.
- **Improvement plans :** Add a **detailed description of the internship and research content at each level** to the Concept (for example, as part of the section on Graduate Internship and Research) . Specify who the supervisors are, what reports are submitted, and how the results are defended. For example, for a Master's internship in industry, specify that the student must solve a specific engineering problem, the results of which will form the basis of the dissertation. For PhD research, specify requirements for publications and conference participation. This will make this component more formalized and of higher quality.

5.4. 4. Interdisciplinarity and Bridge Programs

- **Positive aspect:** The document clearly states the potential for successful MSc and PhD studies for students with non-major backgrounds through bridge programs. The designation of bridge programs as a separate mechanism within the Educational Programs is a strategically important decision.
- **Note:** The description of bridge programs in the text may be somewhat abstract. It's worth **striving for more specificity regarding the types of bridge programs, entry requirements, and the content of the alignment modules** .
- **Improvement plans :** Add a separate subsection to the Concept document **dedicated to mechanisms for interdisciplinary integration and bridge programs** . It should outline sample structures of alignment modules (e.g., which physics/mathematics courses a chemist must take to enroll in a nuclear engineering master's program), requirements for admissions testing, and mechanisms for synergizing backgrounds (how the experience of a chemist or materials scientist will be utilized in the learning process). Adding **specific examples of bridge programs** (which courses, how many ECTS credits) will make this section more convincing and practical.

5.4. 5. Infrastructure and Resources

- **Positive aspect:** The ECTS balance sheet by level takes into account resources for teaching and research. The identification of simulators and specialized modeling codes as key resources is in line with current trends.
- **Note:** The description of infrastructure support may be a bit terse. It would be helpful **to more clearly define the connection between the simulator type and the Vendor Independence Concept** .

- **Improvement plans :** Add a **detailed description of the required infrastructure and resources** to the Concept (e.g., in the resource section) . Specify the types of simulators (e.g., universal multiphysics codes, the Nuclear Island simulator), specialized software, and laboratory equipment. Clearly state in the Concept that the use of **universal, vendor-neutral simulators** is fundamental to implementing the principle of technological indifference. This will emphasize the strategic importance of infrastructure support for the Program.

5.4. 6. Detailing the Role of the Vinča Institute in Syllabi

- **Note:** The Vinča Institute is mentioned as a key partner with unique laboratory facilities. However, the syllabi for specific courses (especially at the master's and doctoral levels) **do not always explicitly state which laboratory work or research modules are implemented at Vinča** .
- **Improvement plans: Add** the following brief instructions to the syllabi of specific engineering and materials science modules (e.g., on the behavior of materials under irradiation or on certain aspects of welding): “ **implemented on the basis of specialized laboratories of the Vinča Institute of Nuclear Sciences** .” This will emphasize the practical value of the partnership.

5.4. 7. Strengthening the Multi-normative Component in the Management Block

- **Note:** The thesis of a multi-normative environment as a guarantee of success is stated in the introduction, but its detailed integration into the management modules' syllabi (particularly in Construction Management at the master's level) **could be more explicit** . Comparison of QA/QC standards from different countries (e.g., French, Chinese, Russian, and EU standards) during the construction process is critically important.
- **Improvement plans: In the "Nuclear Construction Management"** module (Master's program), during the weeks dedicated to QA/QC and logistics, add specific topics on **comparative analysis of regulatory requirements from various vendors and international safety standards** during construction. At the PhD level, add topics on standards harmonization methodology to the seminar syllabus.

5.4.8 . Infrastructure and Types of Simulators

- **Note:** While identifying simulators as resources is accurate, **the connection between simulator type and the concept of vendor independence could be made even more explicit** . Specifying that simulators are "universal" or "multiphysics" is a fundamental advantage.
- **Improvement plans: In the Concept section** describing resources, add a separate paragraph dedicated to the simulator infrastructure. Specify that the program is based on the use of **universal multiphysics simulators (CFD, kinetics, general thermal physics)** , as well as specialized software for the Simulation of Construction Sites ('nuclear island'). This will emphasize the commitment to the principle of technological indifference at the technical level.

5.4.9 . Final ECTS Verification for Bridge Programmes

- **Note:** The section on bridge programs accurately describes the mechanism for individual trajectories. It would be useful **to include an approximate number of ECTS credits** a student can earn within the bridge program to illustrate the extent of the necessary "alignment."
- **Improvement plans** : In the description of bridge program mechanisms, add approximate ECTS credit ranges for equalization modules (e.g., "*from 15 to 30 ECTS depending on background education*"). This will make this section more pragmatic for academic planners.

CONCLUSION

The creation of the Nuclear Engineering Educational Program at the University of Belgrade is a strategic investment in Serbia's energy security, technological independence, and scientific potential. Strict adherence to the approved structure and terminology, detailed development of Syllabi and Modules, and the active involvement of all stakeholders—from faculties to industrial giants—are key to the successful implementation of this interdisciplinary initiative.