СОФИЙСКИ УНИВЕРСИТЕТ „СВ. КЛИМЕНТ ОХРИДСКИ“ основан 1888 г.

BULGARIAN NUCLEAR ENERGY – NATIONAL, REGIONAL AND WORLD ENERGY SECURITY

THE PROBLEM OF NUCLEAR ENERGY PERSONNEL THROUGH THE PRISM OF HIGHER EDUCATION

PLAMEN PETKOV AND GEORGI RAINOVSKI

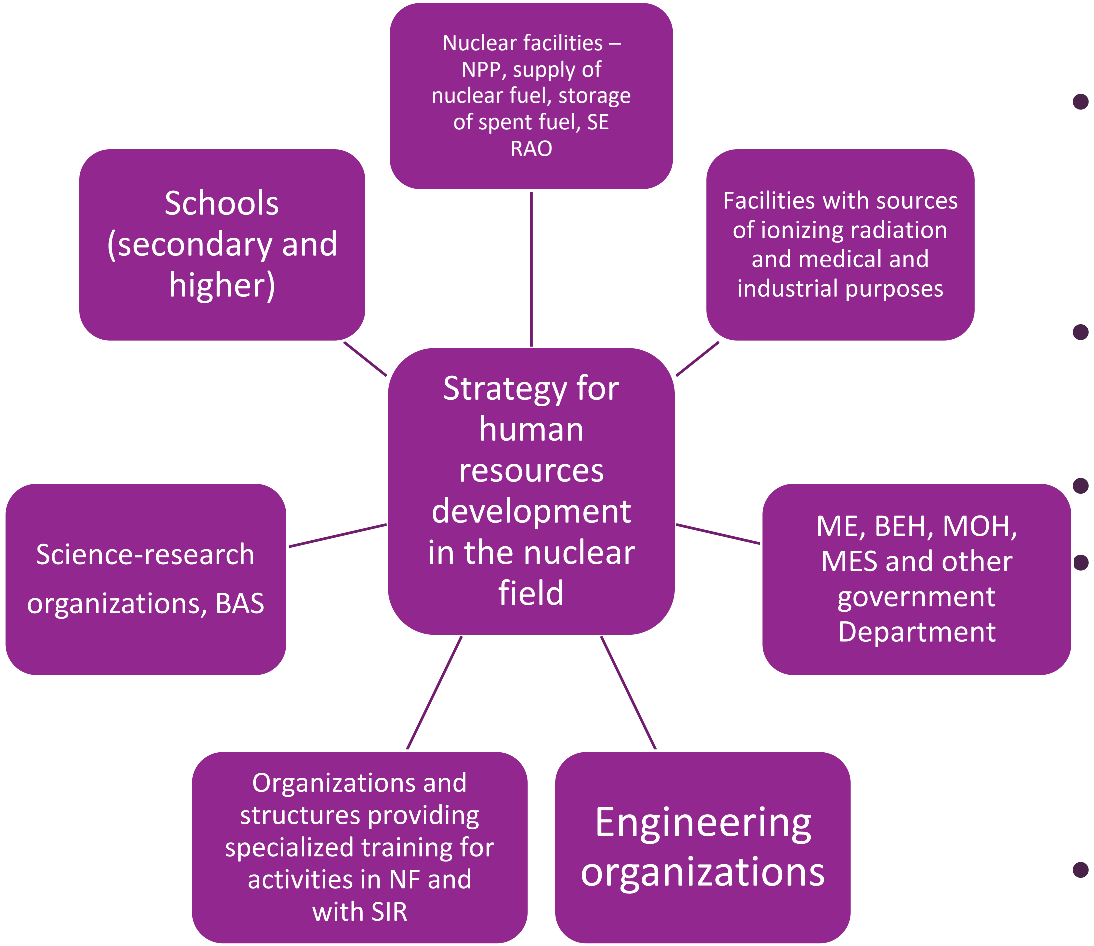
УНИВЕРСИТЕТСКИ ЦЕНТЪР ПО УПРАВЛЕНИЕ НА КАЧЕСТВОТО

BULATOM, VARNA 6 JUNE 2025

Outline

- Expectations in nuclear industry
- Prerequisites: high school education in physics
- Problems and solutions of higher education in nuclear energy and physics
- Good practices of Sofia University “St. Kliment Ohridski”
- Conclusions and future directions

National Strategy for Human Resources Development in the Nuclear Field 2022-2032



- All organizations performing activities related to the safe use of nuclear energy and ionizing radiation,
- Safe management of radioactive waste and spent fuel
- Regulation of facilities and activities,
- Institutions and organizations performing educational, research and development activities related to the use of nuclear facilities
- Locations with sources of ionizing radiation.

Required Number of Specialists in Nuclear Sector within 2021-2030, According to the National strategy

Company	bachelor	Master
Kozloduy NPP Plc	612	527
Kozloduy NPP – New Build Plc		
• AP 1000 project, Kozloduy 7 and 8 units	502 and 803	
• AES 92 Belene 2 units	1109	
State Enterprise "Radioactive Waste"	60	265
Bulgarian Regulatory Agency	114 employment positions, filled 97 of them. The average edge of the personnel is 50 years	
National Center of Radiobiology and Radiation Protection (NCRRP) and regional health inspections	In 2010 – 2020ys staff decreased from 120 staff positions to 102 staff positions. Average staff positions occupied vary in the period from 80 – 85%.	
Institute for Nuclear Research and Nuclear Energy (INRNE) at the Bulgarian Academy of Sciences	In 2011-2021 employed 257 persons, with 56% turnover	
Supporting Nuclear Industry Companies	?	

Total required number of specialists, directly involved in industry more than 4351.
Nothing mentioned about the managerial staff

NATIONAL STRATEGY FOR THE DEVELOPMENT OF HUMAN RESOURCES IN THE NUCLEAR SECTOR, 2022 – 2033

<u>Weaknesses</u> of Nuclear Energy Education in Bulgaria

- The majority of employees in the sector (e.g. at Kozloduy NPP, at SE RAW, at INRNE-BAS, etc.) are over 40 years of age: the share of employees over 40 years of age at Kozloduy NPP is over 73% and the most of them will retire in the next 10 years
- Insufficient attention from institutions and personnel users to the preparation of new personnel for nuclear energy
- Insufficient regulation and quality control of primary and secondary education, which hinders the confidence of prospective students in their ability to cope with the material taught in nuclear majors
- Insufficient material stimulus in key units of the sector, leading to a lack of motivation, needs to increase administrative capacity
- Lack of sufficient and well-equipped facilities for research and experimental activities
- Lack of a systematic approach to attracting young staff – sustainability in decision-making for the development of the nuclear sector, attractiveness of the relevant specialties in the higher education system, opportunities for career development, social mechanisms for attracting young people;
- Insufficient number of students in vocational and higher education schools for the needs of long-term operation of nuclear facilities
- Risk of loss of nuclear and energy knowledge

NATIONAL STRATEGY FOR THE DEVELOPMENT OF HUMAN RESOURCES IN THE NUCLEAR SECTOR, 2022 – 2033

Strengths of Nuclear Energy Education in Bulgaria

- Well-developed regulatory framework, harmonized with EU legislation, which defines the legal framework for state regulation of the safe use of nuclear energy and ionizing radiation, the safe management of radioactive waste and spent fuel, and the rights and obligations of persons to ensure nuclear safety, radiation protection and physical protection
- Fully developed nuclear infrastructure, including regulatory, academic, operating, maintenance and non-governmental organizations
- Developed traditions in the training of specialists working in the nuclear sphere: training in nuclear specialties is carried out at all three educational and qualification levels - bachelor, master and doctor
- Long-standing traditions and experience in the operation of nuclear facilities
- High level of education of those operating nuclear facilities, of qualified and competent personnel with a high safety culture

NATIONAL STRATEGY FOR THE DEVELOPMENT OF HUMAN RESOURCES IN THE NUCLEAR SECTOR, 2022 – 2033

Prerequisites: Education in Physics in Bulgarian High School

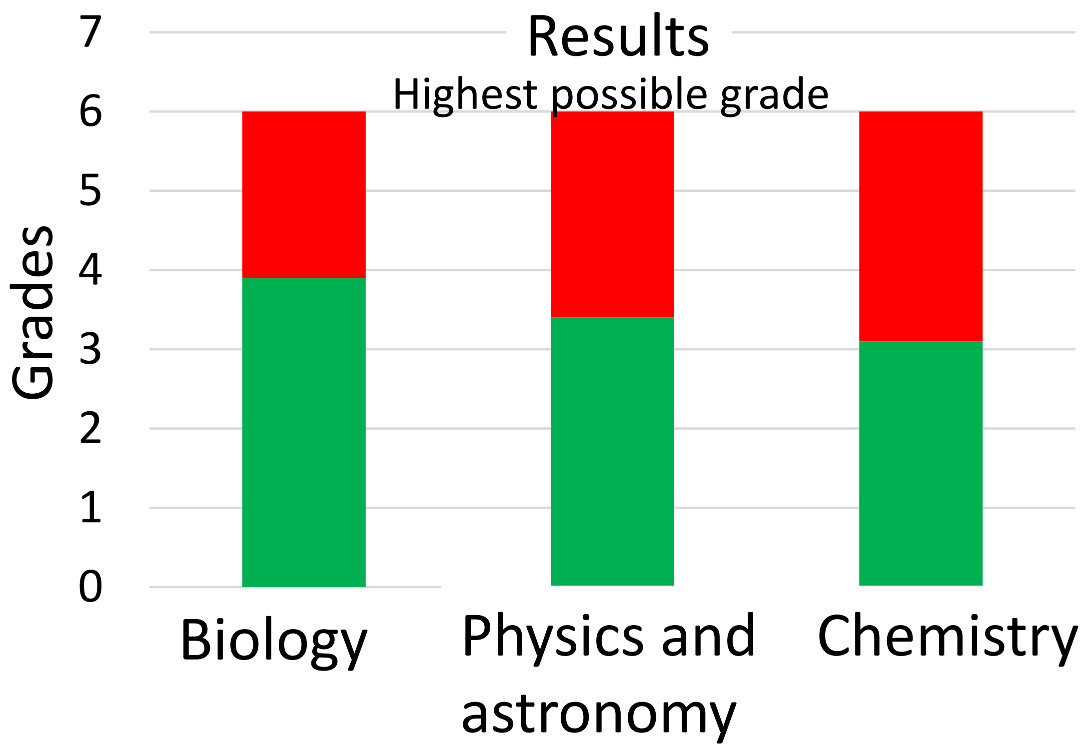
- Since 2015 the new distributes curriculum teaching time between the subjects or modules or activities for acquiring school studies.
- Structure of the curriculum comprises three groups of teaching hours, divided into sections: compulsory, elective and facultative
- Teaching hours in high school VIII-XII grades distributed according to framework and standard curricula
- The framework curricula are according to the level and type of education, specifics and forms of training, and in the secondary level of education - also according to the method of studying a foreign language - intensive, extended or not.

Grade	Number of hours according to framework curriculum	
	Language profiled	Non language profiled
VIII	-	54
IX	90	36
X	72	72
total	162	162
XI	Elective hours in total depending on profiling is 162	
XII		

Ministry of Education and Science

The first National Digital Science Test on 14 and 15 October 2024 for IX Grade

- Was also a test of the system's readiness to organize various exam formats entirely on electronic devices: rightly assumed that experiment failed
- On the second day of the exam, the platform crashed, causing nearly 10,000 students to drop out.
- On the arranged new date for them - October 24, 2,700 students appeared.
- In total, 48,941 students participated in the study, but over 7,000 never tested their skills.



Average grade in Physics and astronomy, 3.40

Sega, 24 Dec. 2024, S. Georgieva

Overview of Current Problems in School

- There is no material base: "Some schools have 2 laboratories - one for chemistry and one for biology, out of 5 teachers, only 2 can use it
- Despite STEM labs development offers good material base, most of the teachers do not have the capacity to use the equipment and tools
- School students' knowledge weak point - critical and analytical thinking - could be improved if there was more project-based learning, an emphasis on developing skills in the classroom, and teamwork.
- The way the concepts are introduced up to grade VII is disputable - for example, students do not know the structure of the atom, but learn about the properties of chemical substances, about valence, try to solve computational problems, etc. "This knowledge is thrust upon them without them really understanding it.
- In grade VIII, school students do not perceive science that is not visible to them and in the language school they do not study physics at all.

Sega, 24 Dec. 2024, S. Georgieva

Is There Gap Between School and Higher Education?

International school are alternative of public education

WHAT ARE THE MOST POPULAR CURRICULUMS IN SOFIA?

Curriculum	International schools
IB	7
British	5
American	4
Montessori	1
German	1
Other	2

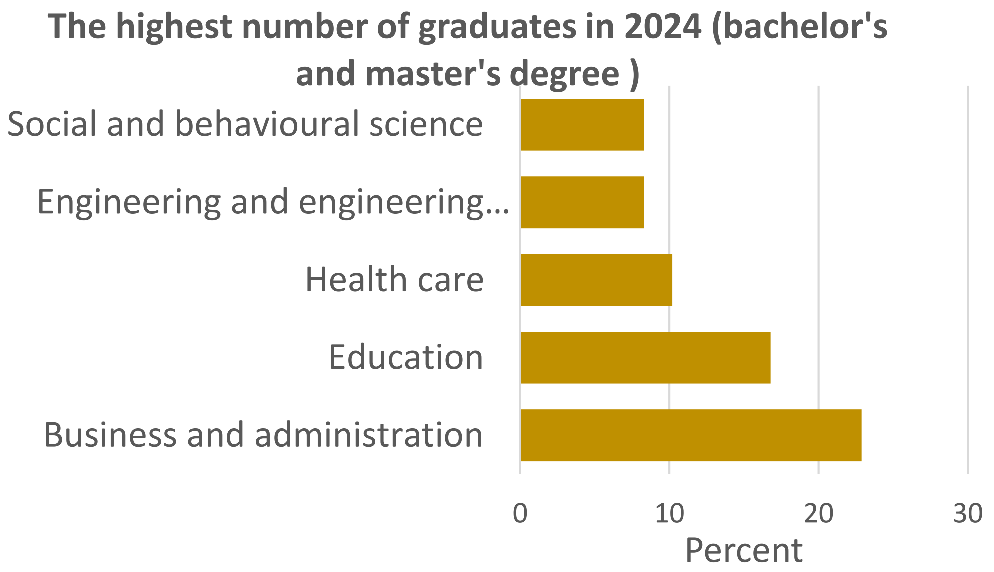
On average, there were 21 students per class in public school

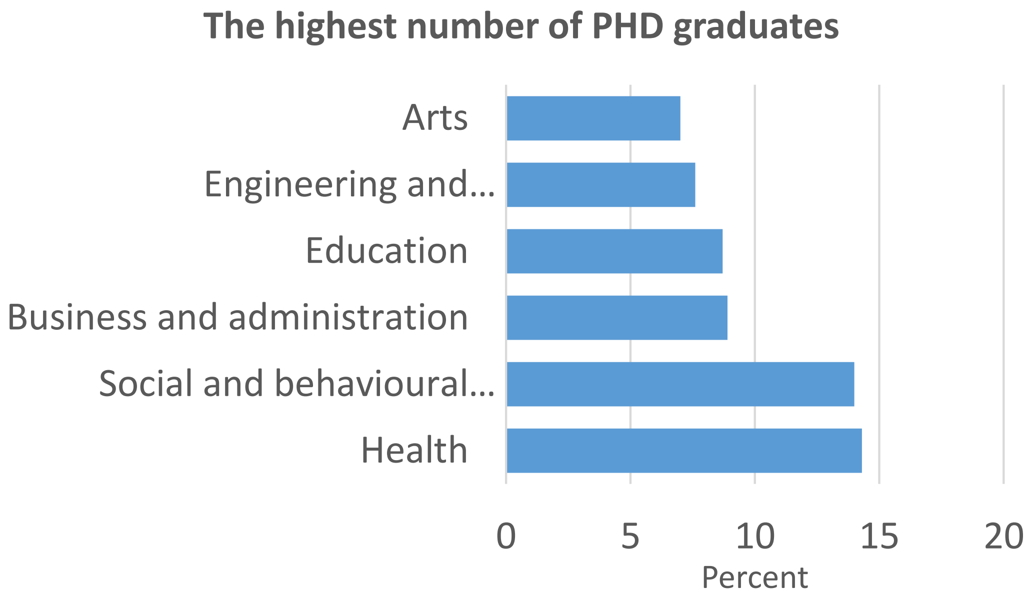
Davinci AI generated image (https://davinci.ai/app)

The average class size of international schools is 15.7 students in 15 schools, all in Sofia.

IB Educational Platform

Most Attractive Professions in 2024





- Engineering and engineering trades are still attractive among the students but not the natural sciences
- Problems arise from the prospectives for realization after the graduation

EDUCATION IN THE REPUBLIC OF BULGARIA FOR 2024/2025 SCHOOL YEAR, National Statistical Institute

Strategic Goals of Higher Education in Nuclear Energy

Goal 1: Enhance Student Success through Educational Excellence: technical thrust areas that comprise undergraduate and graduate programs: (1) fission power reactors; (2) radiation detection and radioisotope applications including nuclear security; (3) plasma science and engineering; (4) nuclear computational science; and (5) nuclear materials.

Goal 2: Enhance Scholarship & Research by Investing in Faculty & Infrastructure development of specialists in sub-areas: (1) renovation of research equipment and development of new laboratories; (2) nuclear reactor safety and severe accident; (3) nuclear security; (4) development of new reactor designs; (5) sensitivity analysis and uncertainty quantification;

Goal 3: Enhance Interdisciplinary Research to Address Grand Challenges: Nuclear engineering is a multidisciplinary field by nature, a fact that is borne out by the field's evolutionary history since the middle of last century: allowing students to enroll in a multitude of courses of different educational programmes, either by requirement or by choice, and this exposes them to other disciplines

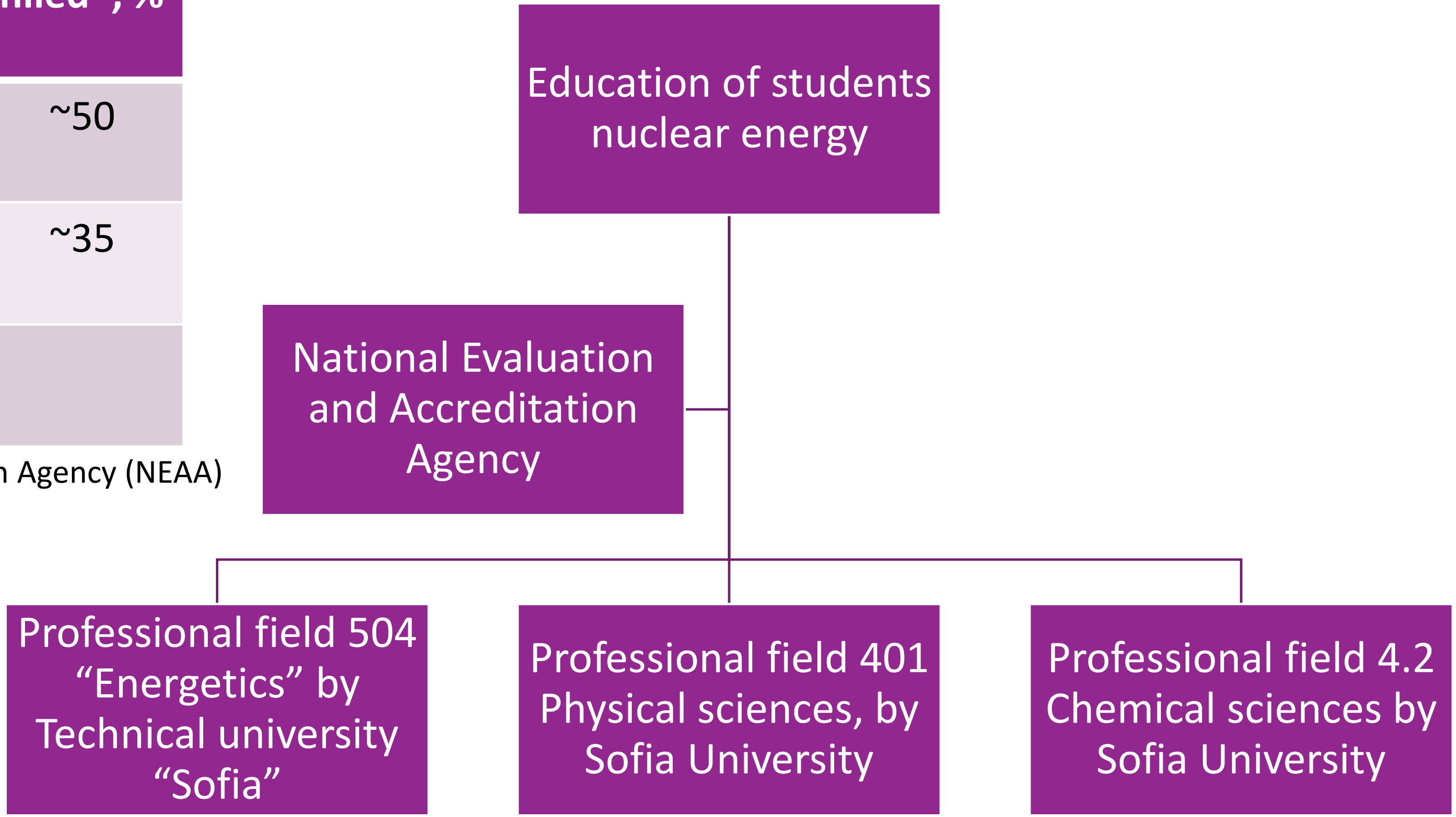
Goal 4: Enhance the Quality of the Operations & Governance Provide the staff with professional growth opportunities to sharpen existing skills and develop new skills that will make them more valuable to the Department's functionality.

Goal 5: Enhance Local & Global Engagement through Strategic Partnerships: Create opportunities for faculty to engage external constituencies by funding their attendance

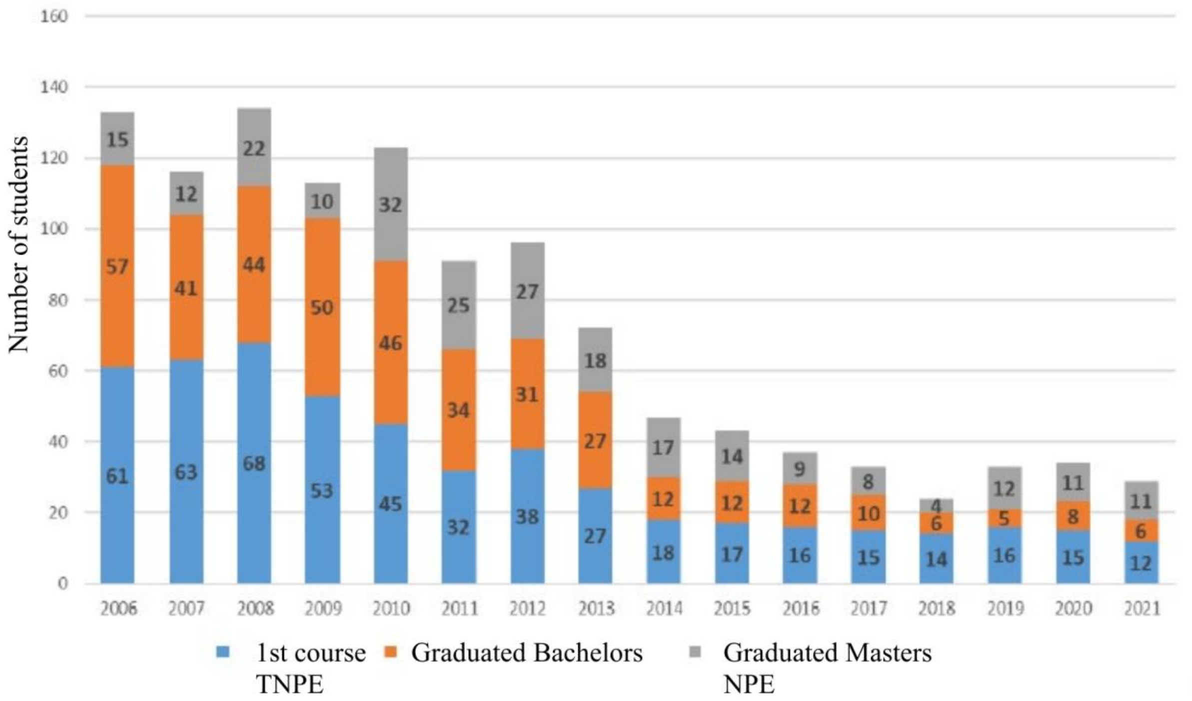
Higher education in Bulgaria, related to nuclear energy

field	Capacity*, persons	filled*, %
Professional field 504 - Energy	3100/2021y	~50
Professional field 401 - Physical Sciences	1200/2025y	~35
Professional field 4.2 Chemical Sciences	1500/2025y	

*determined by the National Evaluation and Accreditation Agency (NEAA)



Enrolled and Graduated Students from 2006 to 2021 in TU Sofia



- Enrolled students in Thermal and Nuclear Power Engineering (TNPE),
- Graduated Bachelors in TNPE
- Graduated Masters in Nuclear Power Engineering (NPE)

Significant declining in numbers

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Number of Enrolled and Graduated Students in Faculty of Physics, SU from 2011 to 2022.

Academic Year	Bachelors		Masters	
	Physics + EP + MP + QSTP + NPP		NPP+MP	
	Enrolled	Graduated	Enrolled	Graduated
2016 / 2017	38	1	12	4
2017 / 2018	48	11	7	2
2018 / 2019	46	10	10	2
2019 / 2020	56	3	7	9
2020 / 2021	55	8	8	5
2021 / 2022	75	–	11	–
Total number:	318	33	55	22

Bachelor's and master's students, in Physics, Engineering Physics (EP), Medical Physics (MP), Quantum and Space Theoretical Physics (QSTP), Nuclear and Particle Physics (NPP)

Bachelors			Masters			
			Enrolled		Graduated	
Academic Year	Enrolled	Graduated	Full-time	Part-time	Full-time	Part-time
2011 / 2012	7	3	2	11	3	4
2012 / 2013	7	4	3	1	3	4
2013 / 2014	9	4	2	2	1	5
2014 / 2015	6	3	3	2	3	4
2015 / 2016	5	4	3	1	2	2
2016 / 2017	3	2	1	–	4	2
2017 / 2018	1	3	–	3	1	–
2018 / 2019	2	3	1	–	–	2
2019 / 2020	7	–	1	3	–	–
2020 / 2021	5	–	2	3	2	3
2021 / 2022	8	–	–	–	–	–
Total number:	60	26	18	26	19	26

Number of enrolled and graduated students in the Bachelor's degree Nuclear Engineering and Nuclear Energy and the Master's degree Nuclear Power Engineering and Nuclear Technology at the Faculty of Physics of Sofia University

Insufficient number of students on entry level , low number of graduates

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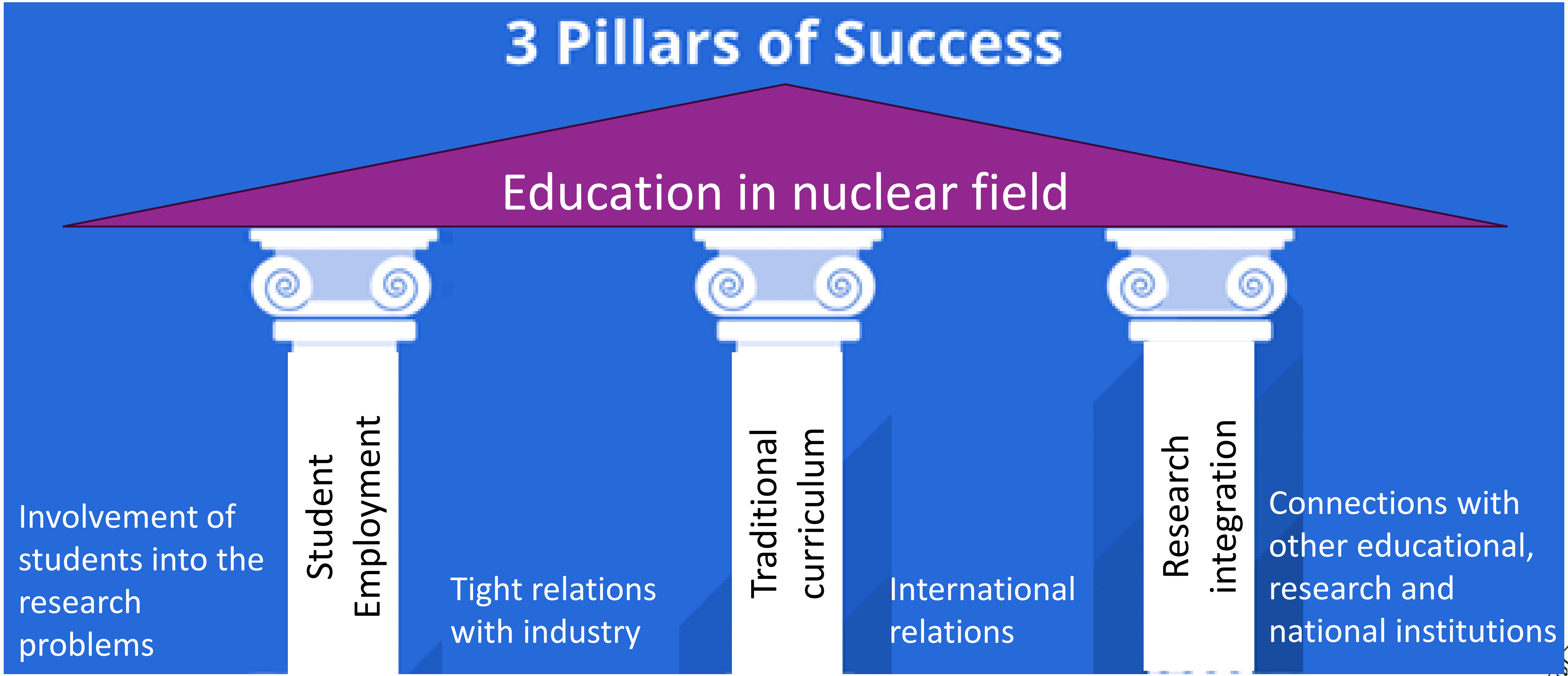
ФИЗИЧЕСКИ ФАКУЛТЕТ

Possible Reasons for Outflow of Students

- Lack of a clear state commitment regarding the future of nuclear energy leading to a lack of clear career development prospects
- Poor material support of the educational process due to insufficient funding
- Outdated material-technical and laboratory base
- Insufficient regulation and control of the quality of education
- Lack of interest in engineering and mechanical specialties and a large admission in the "unprofitable" specialties for the Bulgarian economy
- Insufficient number of classes in natural sciences in the primary and the secondary education
- Negative public attitudes towards nuclear energy in general
- Lack of promotion of the education in the less attractive nuclear specialties
- Lack of clearly expressed interest from users of the workforce

Pillars of Education of Nuclear Field



Educational Programs in Sofia University Related to Nuclear Energy

Faculty	Academic Degree	Program
Physics	**BSc**	Nuclear Technics and Nuclear Energetics (Nuclear Engineering)
Chemistry and Pharmacy	**BSc**	Nuclear Chemistry
Physics	**MSc**	Nuclear Energetics and Technologies
Physics	**MSc**	Medical Physics
Chemistry and Pharmacy	**MSc**	Radiochemistry and Radioecology
Chemistry and Pharmacy	**MSc**	Nuclear Chemistry
Faculty of Economics and Business Administration	**MSc**	Nuclear Technology Management and Innovations
Physics	**PhD**	Neutron and Reactor Physics
Chemistry and Pharmacy	**PhD**	Radiochemistry

Educational Programs in Faculty of Physics

Programme	Acad. Degree	Semesters
Physics	**BSc**	8
Nuclear Technics and Nuclear Energetics (Nuclear Engineering)	**BSc**	8
Engineering Physics	**BSc**	8
Astrophysics, Meteorology and Geophysics	**BSc**	8
Medical Physics	**BSc**	8
Physics and Mathematics	**BSc**	8
Physics and Informatics	**BSc**	8
Quantum and space theoretical physics	**BCs**	8
Comunications and physical electronics	**Bcs**	8
Optometry	**Bcs**	8
Photonics and laser physics	**Bcs**	8
Computer engineering	**Bcs**	8
Natural science teacher in basic degree of education	**Bcs**	8
Quantum, Nuclear and Particle Physics	**Bcs**	8
Wireless Networks and Devices	**MSc**	3/4
Communications and Physical Electronics	**MSc**	2

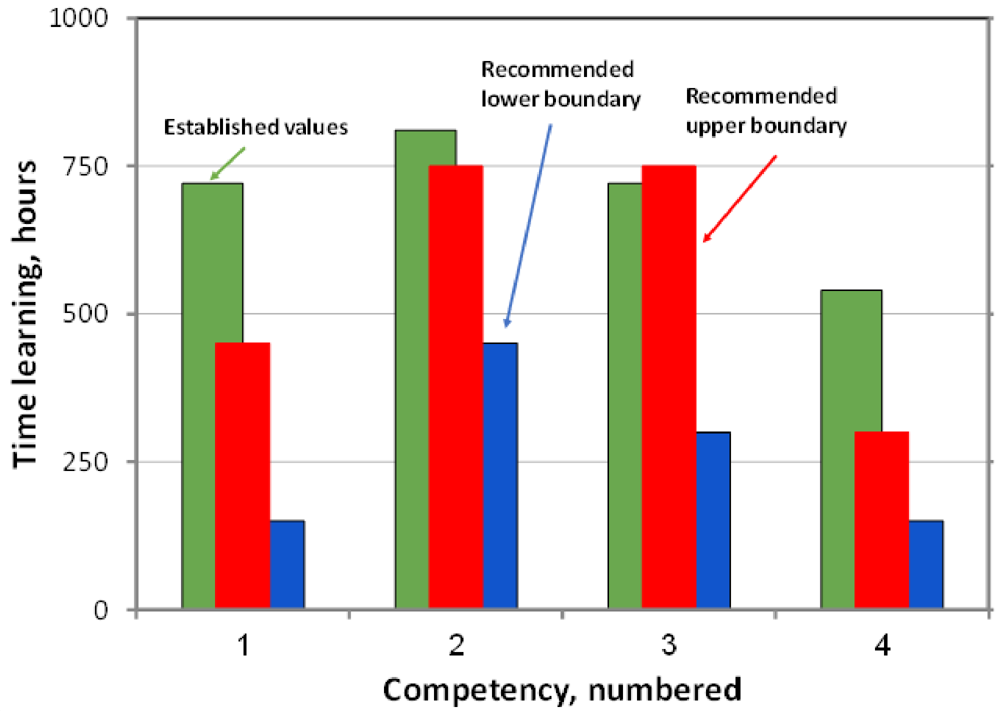
Programme	Acad. Degree	Semesters
Optics and Spectroscopy	**MSc**	3
Theoretical and Mathematical Physics	**MSc**	3
Quantum informatics	**MSc**	3
Nuclear and Particle Physics (BG and ENG)	**MSc**	3/5
Plasma Technology and Thermonuclear Fusion (ENG and BG)	**MSc**	3
Medical Physics (BG and ENG)	**MSc**	3/4
Astronomy and Astrophysics (ENG and BG)	**MSc**	3
Astronomy and popularization of Astronomy	**MSc**	4
Meteorology	**MSc**	3/5
Physics of earth, atmosphere and ocean	**MSc**	4
Geophysics	**MSc**	2/4
Quantum Electronics and Lasers Technique	**MSc**	3
Microelectronics and Information Technologies	**MSc**	3
Nuclear Energetics and Technologies	**MSc**	3/4
Optometry	**MSc**	2/6
Aerospace engineering and communications (BG and ENG)	**MSc**	3
Quantum Technologies (ENG)	**MSc**	3
Methodology of Physics and Astronomy	**MSc**	2/3

Strategic Partnership between Faculty of Physics and Faculty of Economic and Business Administration

- Main goal is to continue the improvement of the education and research in the nuclear sector in Bulgaria.
- Part of partnership is newly established programme, entitled "Nuclear Technology, Management and Innovations" (NTMI), developing jointly with the International Atomic Energy agency (IAEA) and a member of the International Nuclear Management Academy (INMA).
- NTMI designed to educate students to become in the future an interdisciplinary type of managers in nuclear industry, focusing on technology management, including nuclear power, nuclear applications, and radiological technology.
- Students should obtain knowledge not only how to manage large scale complicated industrial nuclear systems and facilities, but also should understand the technological processes, related to the nuclear fuel including production, operation and final waste utilization.

Criteria for INMA Programmes Fulfilled by Sofia University

- Total learning time by the students to be within the range of 1800–4000 hours.
- Coverage of the competences in the INMA programme to achieve 80–85%.
- Provided training activity for 600–1200 hours and research project (master thesis) of 300–600 hours
- Programme should comply the university formal requirements, in order to be accredited by the national accrediting institutions
- Students to develop skills, where they should integrate experimentation, computation and synthesis



1. External environment, Category 1
2. Technology, Category 2
3. Management, Category 3
4. Leadership, Category 4

Core Courses Included in Compulsory Module

- Core courses form the mandatory module, regarding the development of the expected competences
- First academic year courses: No. 1- 5 & 6 - 9 of category No. 1&2 (the first and the second semesters).
- Second academic year courses: No. 10- 13 & 14 – 16 (third and fourth semesters).

No.	Title of the course	A/Cat.	R/Cat.
1	Economics and Management of Nuclear Energy	1/1	1/1
2	Legislation and regulation in the nuclear sector	1/1	2/1
3	Commercial Law and Intellectual Property Management	1/1	1/1
4	Nuclear Sector Security	2/1	1/1
5	National nuclear technology policy, planning and politics	1/1	
6	Nuclear Power Plants, Reactor physics and Nuclear safety	1/2	3/2
7	Detectors and Measurements in Nuclear Technologies	2/3	1/2
8	Decommissioning and Radioactive Waste Disposal		2/1
9	Radioactivity, Safety and Environmental Protection		2/2
10	Human Resources Management in the Nuclear Industry		4/3
11	Nuclear Safety and Nuclear Incident Management		3/3
12	Management in the Nuclear Industry		4/3
13	Performance Monitoring and Quality Assurance		4/3
14	Strategic Management and Leadership in Nuclear organizations		3/4
15	Internal and External Communications		3/4
16	Knowledge Management and Nuclear Safety Culture	1/4	2/4

Specializations in SU INMA Programme

- Large nuclear facilities: the student to be focusing on the existing nuclear facilities which includes the currently operating nuclear power plants
- Small modular reactors (SMR): new field that requires special attention to be established safety, performance and economics of newer nuclear technology, while implementing in industrial scale. <u>Unlike the traditional nuclear industry, the managers there cannot be created based on the practical experience.</u>
- Programme is not limited to the selection of the one of these modules: students may wish to take courses that belongs to both modules: In this case their specialization is determined, based on their written master's thesis.

planned mainly as part time – four semester, 120 ECTS

The specialization is determining the topic for the thesis.

Small modular reactors

Large nuclear facilities

IAEA Endorsement Process to Become a Part of INMA

Sofia University endorsement by IAEA INMA Academy

1. university formally requests an INMA Peer Review Mission to assist with the establishment of an INMA NTM Programme
2. Self assessment of newly designed or existing programme(s), submission preliminary Information Package to the IAEA
3. The INMA Peer Review Mission to assist the university takes place
4. University developed and implements INMA programms
5. Self assessment of NTM programme and submits a complete assessment Information Package
6. INMA Peer Review Mission to assess the NTM programme implementation and the assessment report provided to the university
7. The university provides feedback on the main findings of the mission and recommendati ons made in the report, if any

https://www.iaea.org/topics/nuclear-knowledge-management/international-nuclear-management-academy

INMA
International Nuclear Management Academy
IAEA

SOFIA UNIVERSITY
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THIS IS TO CERTIFY THAT

The International Atomic Energy Agency
recognizes the

MASTER'S DEGREE IN NUCLEAR TECHNOLOGY, MANAGEMENT AND INNOVATIONS

at Sofia University "St. Kliment Ohridski"
Sofia, Bulgaria

AS AN INTERNATIONAL NUCLEAR MANAGEMENT ACADEMY
ENDORSED PROGRAMME

Mikhail Chudakov
Deputy Director General
Head of the Department of Nuclear Energy
International Atomic Energy Agency

9 December 2024

Admission in the newly created programme:

- In 2024, 17 students.
- In 2025, 13 students.

Internships/Early Employment Strategy

- The gap between academic knowledge and practical skills is becoming increasingly evident in the job market, underscoring the importance of integrating real-world applications into educational frameworks.
- As industries advance rapidly, the demand for specialists who are not only educated but also employable is increasing but traditional educational frameworks, while foundational, often have problems in preparing students for the real-world challenges
- Internships and industry partnerships serve as vital bridges connecting academic learning with practical application, ensuring that students are not just theoretically proficient but also “industry-prepared.”
- Internships /Early Employment and industry collaborations are essential for developing practical competencies, providing students with opportunities to apply theoretical knowledge in real-world tasks, cultivate professional skills, gain industry-specific insights, and build professional connections.
- Practical experiences like internships /Early Employment allow students to test and refine their skills, stay updated with industry trends, and establish connections that can lead to mentorship and job offers. By aligning educational programs with these industry demands, institutions can ensure their graduates are equipped with the practical skills and insights

Sofia University Relations with Industry (MoUs)

Bulgarian Nuclear Regulatory Agency, summer internships and employment after graduation

Series of AP1000 introductory lectures online/in person

Westinghouse Electric summer internships in the USA and early employment, lectures

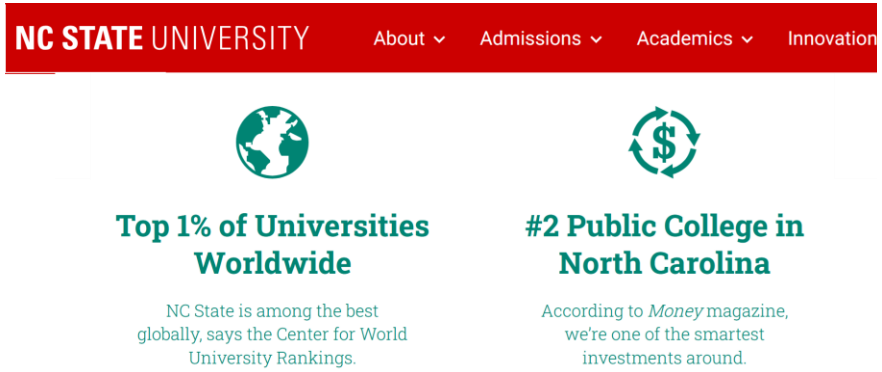
Sofia University

State Enterprise "Radioactive Waste", (MoU), summer interships, schools, employment after graduation

Lecturers from KZNPP in 2025/2026 academic year:
1. "Operational Reactor Physics and Nuclear Safety I"
2. "Computational Reactor Physics"

Kozloduy Nuclear Power Plant, (KzNPP), summer interships, stipends and employment after graduation

Sofia University International Connections



Invited professors from NCSU:
In 2025/2026 academic year,
Delivered course: Neutronic physics

European Industrial Alliance on SMRs

Sofia University

North Carolina State University (MoU)

European Nuclear Educational Network (membership)

СОФИЙСКИ УНИВЕРСИТЕТ „СВ. КЛИМЕНТ ОХРИДСКИ" ФИЗИЧЕСКИ ФАКУЛТЕТ

Internships/Fellowships and Early Employment of Students in Faculty of Physics in Sofia University

Type of degree	Major	Year	students Summer internships company		Students/Early employment company		Students/Employment after graduation	
Bachelor	NTNE	2023	5	Kozloduy NPP			4	Kozloduy NPP
	NTNE	2024	5 3 1	Kozloduy NPP Westing. El. BNRA	3	Westing. El.	1	Kozloduy NPP
	NTNE Other	2025	4 3	Kozloduy NPP Westing. El.	2/WE		4	Kozloduy NPP
Master	NET	2025	1	Kozloduy NPP				
	NET	2024	1	Westing. El.	1	Westing. El.		
	NET	2025	1	Kozloduy NPP				
	NET	2024	1	**IAEA Marie Sklodowska-Curie Fellowship Programme for two years of study**				
	NET	2025	1					

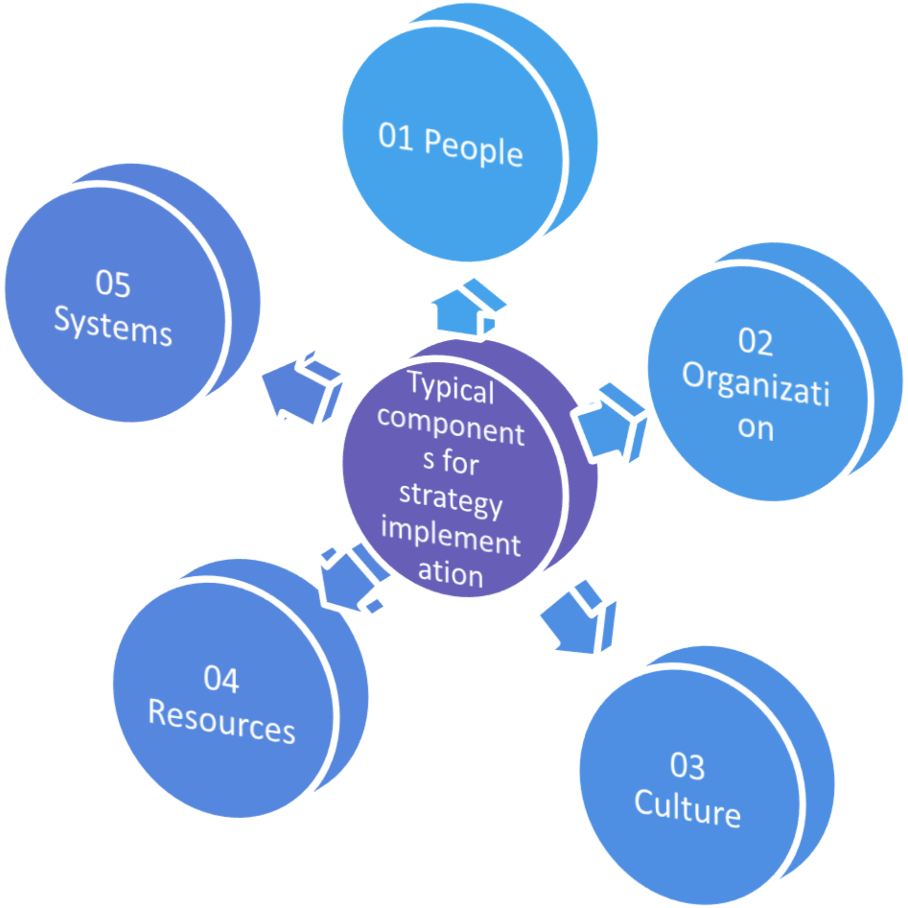
ФИЗИЧЕСКИ ФАКУЛТЕТ „СВ. КЛИМЕНТ ОХРИДСКИ" …РСИТЕТ

Goals of Research Programme in Sofia University in the Field of Nuclear Engineering

- Improving and support of nuclear safety, security, safeguards, radiation protection, safe spent fuel and radioactive waste management and decommissioning, including the safe and secure use of nuclear power and of non-power applications of ionizing radiation
- Maintain and further develop expertise and competence in the nuclear field within the community
- Support the policy of the EU and its members on continuous improvement of nuclear safety, safeguards and security
- Development of strong links between nuclear engineering science and business implementation
- Involving students in motivated research

ФИЗИЧЕСКИ ФАКУЛТЕТ
СОФИЙСКИ УНИВЕРСИТЕТ „СВ. КЛИМЕНТ ОХРИДСКИ“

Conclusions



- Bulgarian government recognizes the problems in development of specialists in nuclear energy field by introducing of a National strategy for human resources development in the nuclear field 2022 – 2032
- However, any strategy implementation is the process of turning strategic plan into action
- Having a strategic plan is great, but unless have the bandwidth, resources, and support to implement plan it’s not going to drive actual change in the field

Future Expectations
(steps to any strategy successful implementation)

1. Strategy framework selection: Clearly to be identified, aligned the goals and key variables of the strategy
2. Building plan and set clear goals: Create focus and driving accountability by delegating work
3. Defining key performance indicators (KPIs) and projects: allocation of the necessary resource and put the strategic plan into action
4. Dealing with “business-as-usual”: Shift the goals or approach to work around unforeseen issue if they arise
5. Implementation of consistent & simple strategy reports: connect with every organization involved in the project to confirm that their work feels complete
6. Linking of performance management with strategic management: Reflections on the implemented strategy to uncover lesson learned for future projects

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Thank you for the attention!!!