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Competence mapping at industry level

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EXECUTIVE SUMMARY

The objective of Work Package (WP) 6, "Internationalization and Stakeholder Involvement," is to leverage the support of extra-EU organizations to enhance human resource development within the EU and beyond. To effectively manage both current and future nuclear technologies, a highly skilled and qualified workforce is essential. WP 1 has already identified a significant shortage of personnel in the nuclear industry, a gap that will only widen with anticipated developments.

Existing education and training (E&T) institutions within the EU are expected to struggle to supply the necessary workforce at the required pace. Additionally, the implementation of extra-EU technologies in various EU countries necessitates safe and competent operation, further underscoring the need for a robust and well-trained human resource base.

Within Task 6.1 important aspects are dealt with. Competence mapping is essential for identifying industry needs and gaps in the Education and Training (E&T) domain, particularly within the EU. This process helps to determine the necessary expertise required and highlights the shortages due to a lack of specialists or adequate infrastructure. Some regions, such as the US and Asia, are more advanced in key areas like Small Modular Reactors (SMRs). International organizations, including OECD-NEA with its NEST initiative, are fostering global cooperation to build competence.

Gap assessments in nuclear research and training will address gaps in nuclear E&T and supply specialists for these the E&T activities. Several new project opportunities have been identified within the EU, such as SMR reactor implementations in Poland and Romania and dealing with workforce attrition in CANDU reactors.

New nuclear builds, particularly from the French perspective, require a qualified workforce, especially for projects in non-EU countries. Advances in nuclear technologies and synergies with other energy sources create an environment ripe for exploring new capabilities in the nuclear sector.

The European Commission, particularly through EHRO-N and WP1 analyses, aims to quantify future competencies needed in the nuclear industry and assess the existing expertise pool. With the support of international organizations like OECD-NEA and JRC, a global expertise assessment will be conducted, followed by proposed E&T actions. This effort aligns with WP5, which supports mobility initiatives within the project.

Current deliverable addresses the identification of gaps found in WP 1 comparing them with the EU situation. Recent activities by the European Commission, particularly through the European Human Resources Observatory for the Nuclear Sector (EHRO-N), and WP1 analysis will quantify future competencies needed in the nuclear industry and the existing expertise pool. Supported by international organizations like OECD Nuclear Energy Agency (OECD-NEA) and EC Joint Research Centre (JRC), a comprehensive assessment of global expertise will be conducted, followed by proposed targeted Education and Training (E&T) actions.

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1 INTRODUCTION

The European union is facing a real issue in ensuring the future workforce both for the existing power plants but also for the new prospects. Ageing attrition and new necessities brought the nuclear industry to a harsh reality: the human resource is in high demand. The skilled and qualified human resource takes time to educate and train. The nuclear industry needs to maintain a high standard of education and training of its human resource in order to maintain the safe operation of nuclear installations and maintain (and improve) the population trust in the nuclear sector. The human resource is needed in a significant number over a short-to-medium period of time. When it comes to new nuclear technologies, we can mention the big hype recently observed for the Small Modular Reactors (SMRs) but also for the oversees technologies that are implemented at the level of EU member states (e.g. the Korean APR1000 technology chosen by the Czech Republic on July 2024).
SMR it has a great potential and a great market. SMR technologies are widely developed today globally, and they can be split into land-based technologies or marine-based technologies. Among the land-based technologies, even them can be split into several types. The most common types are:

1. Water cooled SMRs
2. High Temperature Gas Cooled SMRs
3. Liquid Metal Cooled SMRs
4. Molten Salt SMRs and
5. microreactors

According to Advances in Small Modular Reactor Technology Developments [1] many of these technologies are developed outside EU:

- CAREM (CNEA, Argentina)
- ACP100 (CNNC,China)
- CANDU SMRTM (Candu Energy Inc, Canada)
- CAP200 (SPIC/SNERDI, China)
- DHR400 (CNNC, China)
- HAPPY200 (SPIC, China)
- NHR200-II (Tsinghua University and CGN, China)
- **TEPLATOR (UWB Pilsen & CIIRC CTU, Czech Republic)**
- **NUWARD (EDF, France)**
- **LDR-50 (VTT Technical Research Centre of Finland)**
- IMR (Mitsubishi Heavy Industries, Japan)
- i-SMR (KHNP & KAERI, Republic of Korea)
- SMART (KAERI, Republic of Korea and K.A.CARE, Saudi Arabia)
- RITM-200N (JSC “Afrikantov OKBM”, Russian Federation)
- VK-300 (NIKIET, Russian Federation)
- KARAT-45 (NIKIET, Russian Federation)
- KARAT-100 (NIKIET, Russian Federation)
- RUTA-70 (NIKIET, Russian Federation)
- STAR (STAR ENERGY SA, Switzerland)

- Rolls-Royce SMR (Rolls-Royce SMR Ltd, United Kingdom)
- VOYGR (NuScale Power Corporation, United States of America)
- BWRX-300 (GE-Hitachi Nuclear Energy, USA and Hitachi-GE Nuclear Energy, Japan)
- SMR-160 (Holtec International, United States of America)
- Westinghouse SMR (Westinghouse Electric Company LLC, United States of America)
- mPower (BWX Technologies, Inc., United States of America)
- OPEN20 (Last Energy Inc., United States of America)
- HTR-PM (Tsinghua University, China)
- STARCORE (StarCore Nuclear, Canada, United Kingdom and United States of America)
- **JIMMY (JIMMY ENERGY SAS, France)**
- GTHTR300 (JAEA Consortium, Japan)
- GT-MHR (JSC “Afrikantov OKBM”, Russian Federation)
- MHR-T Reactor (JSC “Afrikantov OKBM”, Russian Federation)
- MHR-100 (JSC “Afrikantov OKBM”, Russian Federation)
- AHTR-100 (Eskom Holdings SOC Ltd., South Africa)
- PBMR®-400 (PBMR SOC Ltd., South Africa)
- HTMR100 (STL Nuclear (Pty) Ltd., South Africa)
- EM2 (General Atomics, United States of America)
- FMR (General Atomics, United States of America)
- Xe-100 (X-energy, LLC, United States of America)
- SC-HTGR (Framatome Inc., United States of America)
- PeLUIt/RDE (BRIN, Indonesia)
- HTR-10 (Tsinghua University, China)
- HTTR (JAEA, Japan)
- BREST-OD-300 (NIKIET, Russian Federation)
- ARC-100 (ARC Clean Energy, Canada)
- 4S (Toshiba Energy Systems & Solutions Corporation, Japan)
- MicroURANUS (UNIST, Republic of Korea)
- **LFR-AS-200 (newcleo srl, Italy)**
- SVBR (JSC AKME Engineering, Russian Federation)
- **SEALER-55 (LeadCold, Sweden)**
- Westinghouse Lead Fast Reactor (Westinghouse Electric Company, USA).
- IMSR400 (Terrestrial Energy Inc., Canada)
- SSR-W (Moltex Energy, Canada)
- smTMSR-400 (SINAP, CAS, China)
- **CMSR (Seaborg Technologies, Denmark)**
- **Copenhagen Atomics Waste Burner (Copenhagen Atomics, Denmark)**
- FUJI (International Thorium Molten-Salt Forum, Japan)
- **THORIZON (THORIZON B.V., Netherlands)**
- SSR-U (Moltex Energy, United Kingdom)
- KP-FHR (Kairos Power, United States of America)
- Mk1 PB-FHR (UC Berkeley, United States of America)

- MCSFR (Elysium Industries, USA)
- LFTR (Flibe Energy, United States of America)
- ThorCon (ThorCon International, United States of America and Indonesia)

The sixty-four types of reactors presented above include Water cooled SMRs, High Temperature Gas Cooled SMRs, Liquid Metal Cooled SMRs and Molten Salt SMRs. Out of the 64 technologies, only 9 (nine) are developed at the level of EU (UK not included) given a ratio of only 14% of them being developed within EU. Statistically speaking there is a high chance that EU countries might chose already a non-EU developed technology (e.g NUWARD in Romania).

Several initiatives were started in order to estimate what is the actual number of persons needed at EU level and what are the qualifications needed.
Among them, the first work package (WP) of the ENEN2plus EC funded project which deals with finding the number of persons needed by the nuclear industry (task T1.1), Research Safety and Waste management institutions (Task 1.2) and for the non-power applications (Task 1.3).

Another EC funded initiative which deals with analysing the competencies needed in for SMRs and their availability across EU is the TANDEM project. A deep analysis was performed also in this project with respect to necessary competences to be developed for the SMR technologies. A deep review of existing E&T offers (Annex 1) was performed in order to assess whether or not the Educational “institutions are ready to fulfil the demands for these types of rectors. Annex 1 should also be considered as a starting point for the competencies that E&T institutions are able to provide today to the nuclear industry. Several important findings were presented in that report. One of them refers to the job categories and identified skills needed for a new NPP (see tables 1 and 2).

Table 1. Job categories required for new NPPs as identified in EC funded TANDEM project

All engineering disciplines	All technician disciplines (electrician, welders, etc)
Large project management & project control disciplines (including cost control & planning)	Nuclear safety
Licensing, permitting and procurement	Operations management (procedures, instructions, practices, etc)
Information technologies	Digitisation
Waste management	Chemistry
Physics	

Table 2 Needed skills for construction and operation of new NPPs as identified in the EC funded TANDEM project

HARD SKILLS	SOFT SKILLS
Nuclear safety	Problem-solving and analytical skills
Nuclear security & safeguards	Organisational ability

Licensing	Excellent spoken and written communication skills
Component performance	Ability to visualise complex processes
Electrical engineering	Creativity and persistence in work activities
Civil engineering	Ability to order information logically and clearly so others can follow their lead and instructions
Construction	Accountability
Welding	Teamwork
Non-Destructive Examination	Questioning attitude
Project management	Work Autonomy
Maintenance and inspections	Adaptability
Planification and cost estimation	Resilience
Mathematical and computer skills	

In the table above, one can observe a multitude of skills (including soft skills) that are necessary to run a new NPP, skills that can only be acquired from other institutions, other than traditional nuclear engineering schools.

1.1 Overview of the Report on HR Needs in the Nuclear Industry at EU level (ENEN2plus - WP1)

The ENEN2plus WP1 related report analyses the needs of the industry at the level of 2035 and it was elaborated in 2023. Since the date of issue several positive prospects appeared in the nuclear sector, including at EU level. The nuclear industry in the EU27+UK faces significant human resources (HR) challenges and opportunities over the next decade. Based on the analysis performed it was identified that there are two major job categories that are needed in nuclear:

- purely nuclear where nuclear education and training is needed at the highest level and
- nuclear related – where nuclear education and training is required at a lower level.

New human resource perspectives arise from the need to replace retiring personnel, expand capacities with new plants and adapt to evolving technological and safety standards. The following basic findings could be distinguished:

Current Workforce and Retirement Challenges

- The nuclear industry employs a highly skilled workforce across various subsectors, including plant operation, maintenance, safety, R&D and waste management.
- A significant portion of the current workforce is approaching retirement age, necessitating substantial recruitment to maintain operational capacity. It is estimated that between 76,000 and 95,000 purely nuclear jobs will need to be filled by 2035 to replace retirees and sustain current operations.

Future Workforce Demand Scenarios

- Three scenarios outline future workforce needs:
  a) Baseline Scenario: Maintaining the current 109 nuclear plants requires 30,000 new recruits by 2035.
  b) Moderate Growth Scenario: Expanding to 115 plants increases the demand to 40,000 recruits.
  c) High Growth Scenario: Expanding to 122 plants further increases the requirement, emphasizing the need for up to 50% of the current workforce.

- A larger number of new reactors, including small modular reactors (SMRs), are planned to reach the 150 GW capacity by 2050, demanding even more workforce adjustments.

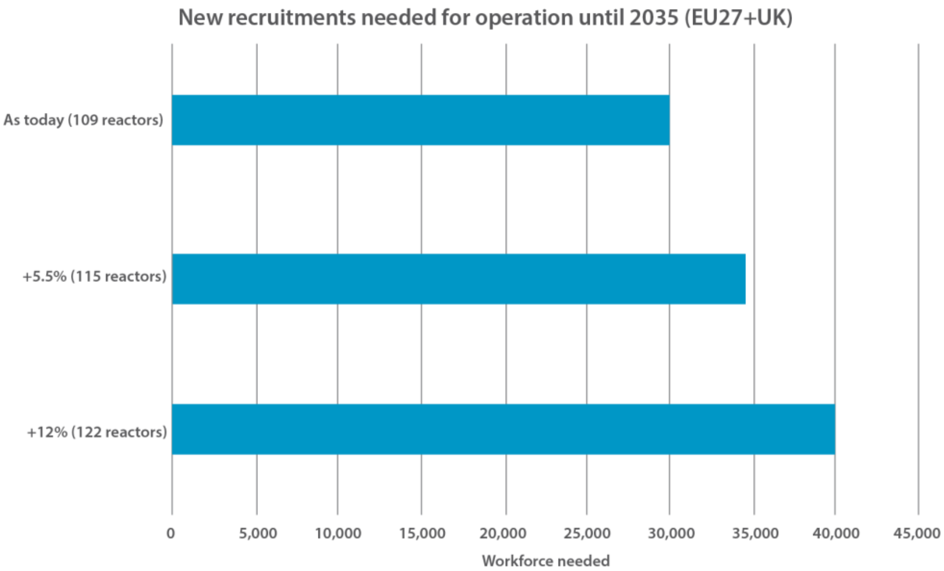

Figure 1: Future Workforce Demand Scenarios

- Scenario 1: 30,000 new recruits needed
- Scenario 2: 40,000 new recruits needed
- Scenario 3: 50,000 new recruits needed

Skills and Competencies in Demand

- High demand for technical roles such as project managers, process engineers, construction engineers, and radiation protection experts.
- Increasing need for multidisciplinary skills, combining technical expertise with soft skills like leadership, communication, and problem-solving .
- Specific nuclear-related competencies such as reactor physics, nuclear chemistry, and decommissioning are critical.

Educational and Training Needs

- Closer collaboration between industry and educational institutions is essential to align curricula with industry needs.
- Emphasis on lifelong learning and continuous professional development to keep pace with technological advancements and safety standards.
- Enhanced support for scholarships, grants, and training programs to attract new talent and upskill current workers.

Upon the analysis performed the report provides the number of recommendations. It stresses that to ensure the strategic planning of the workforce, it is essential to implement National Nuclear Workforce Assessments (NWAs). These assessments will help in mapping the current workforce, predicting future needs and identifying gaps in skills and training. Alongside this, developing a comprehensive nuclear skills strategy at both the national and EU levels is crucial for a coordinated approach to workforce development.

Investment in education and training is another critical area. Strengthening partnerships between industry and educational providers will help create tailored training programs. Promoting nuclear careers through targeted outreach and supporting STEM education will attract more talent to the field. Establishing mentorship and internship programs will facilitate the transfer of knowledge from retiring experts to new recruits.

Fostering diversity and inclusion within the nuclear sector is necessary. Encouraging greater participation of women and underrepresented groups and developing policies and initiatives to create an inclusive work environment will promote diverse perspectives.

Retention and professional development are also important. Creating a supportive work environment with competitive compensation, career development opportunities, and work-life balance initiatives will help retain employees. Implementing retention strategies such as mentorship programs, recognition schemes and continuous learning opportunities will further support professional development.

Lastly, promoting mobility and career flexibility is vital. Facilitating job rotation and cross-functional training will enhance employee skillsets and career development. Encouraging mobility within the EU will help address regional disparities in workforce availability and demand.

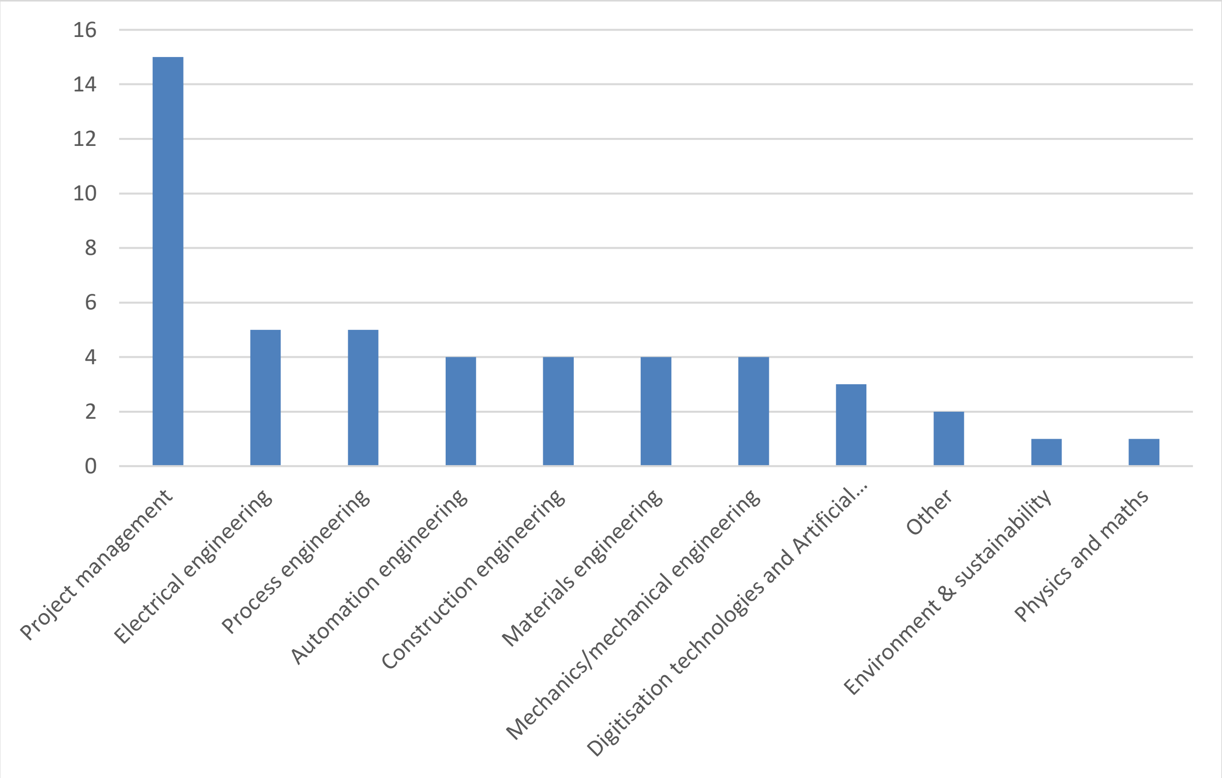

Figure 2: Key Skills and Competencies in Demand

- High demand for project managers, engineers, and radiation protection experts.
- Growing importance of multidisciplinary skills and soft skills.

1.2 Overview of the EHRO-N Report "Results of Surveys of the Supply of and Demand for Nuclear Experts within the EU-28 Civil Nuclear Energy Sector"

The report "Results of Surveys of the Supply of and Demand for Nuclear Experts within the EU-28 Civil Nuclear Energy Sector," published by the European Human Resources Observatory for the Nuclear Sector (EHRO-N), presents a comprehensive analysis of the current state and future needs of human resources in the nuclear industry within the EU. The report, based on surveys conducted in 2018, provides valuable insights into the HR challenges faced by the nuclear sector and proposes strategic actions to address these issues.

The nuclear industry plays a critical role in the EU's energy mix, contributing over 25% of the electricity and more than 50% of low-carbon electricity. Given its importance, ensuring a skilled workforce is crucial for maintaining safe and efficient operations. The EHRO-N surveys aim to identify gaps in the supply and demand for nuclear experts, thereby guiding policy and educational initiatives.

Survey Methodology and Data Collection

The surveys targeted two primary groups: higher education institutions (HEIs) and nuclear stakeholders. The HEI survey assessed the supply side by collecting data on nuclear engineering students, graduates, and gender distribution. In contrast, the stakeholder survey focused on the demand side, gathering information on nuclear staff, their educational background, age distribution, and business trends.

The methodology involved developing detailed questionnaires, distributing them via email, and collecting responses through follow-up calls. While the response rates were lower than previous surveys (40% from HEIs and 38% from stakeholders), the data collected provided a robust basis for analysis.

Key Findings on HR Needs

1. Age Distribution and Retirement: A significant portion of the nuclear workforce is approaching retirement age, particularly in the age groups 45-55 and above 55. These categories have increased from 50% in 2010 to 56% in 2018, indicating a pressing need to recruit and train new experts to replace the retiring workforce.

2. Gender Balance: The gender balance in nuclear experts has shown some improvement, with 43% of nuclear experts being female. However, there is still a disparity, especially in technical and engineering roles where female participation is lower compared to administrative functions.

3. Nuclear Staff Categories: The distribution of nuclear staff varies across different categories. Nuclear experts constitute around 43% of the workforce, with the remaining being nuclearized staff (STEM professionals without formal nuclear education) and support/administrative staff. The report highlights an increased proportion of support staff compared to previous surveys.

4. Sectoral Distribution: The employment distribution across sectors shows significant changes. Utilities, which accounted for 50% of nuclear experts in 2010, now represent only 7%. Conversely, the design, engineering, manufacturing, and maintenance sector has grown, indicating a shift in the industry's focus areas.

5. Decommissioning Needs: The survey also highlighted the growing demand for experts in nuclear decommissioning. While the current workforce in this area is around 7,000, it is projected to increase by 30% by 2030, reflecting the sector's evolving needs.

6. Recruitment Trends: The business situation in the nuclear sector has been relatively stable, with 63% of stakeholders reporting stability in recent years. Recruitment has slightly outpaced departures, indicating a positive trend in workforce growth.

Recommendations

The report emphasizes the need for strategic workforce planning to address these HR challenges. It recommends the implementation of National Nuclear Workforce Assessments (NWAs) to map the current workforce, predict future needs, and identify skills gaps. Developing a comprehensive nuclear skills strategy at both national and EU levels is essential for a coordinated approach to workforce development.

Investment in education and training is crucial. Strengthening partnerships between industry and educational providers can create tailored training programs. Promoting nuclear careers through targeted outreach and supporting STEM education will attract more talent to the field. Additionally, establishing mentorship and internship programs will facilitate knowledge transfer from retiring experts to new recruits.

Fostering diversity and inclusion is another critical area. Encouraging greater participation of women and underrepresented groups in the nuclear sector and developing policies to create an inclusive work environment will promote diverse perspectives.

Retention and professional development are vital for maintaining a skilled workforce. Creating a supportive work environment with competitive compensation, career development opportunities, and work-life balance initiatives will help retain employees. Implementing retention strategies such as mentorship programs, recognition schemes, and continuous learning opportunities will further support professional development.

Promoting mobility and career flexibility is essential. Facilitating job rotation and cross-functional training will enhance employee skillsets and career development. Encouraging mobility within the EU will help address regional disparities in workforce availability and demand.

1.3 Conclusion for EHRO-N "Results of Surveys of the Supply of and Demand for Nuclear Experts within the EU-28 Civil Nuclear Energy Sector" and "HR Needs in the Nuclear Industry"

The nuclear industry within the EU faces a critical juncture characterized by both challenges and opportunities in managing its human resources. Both reports, "Results of Surveys of the Supply of and Demand for Nuclear Experts within the EU-28 Civil

Nuclear Energy Sector" and "HR Needs in the Nuclear Industry," provide a comprehensive overview of the current and future HR landscape, highlighting the need for strategic action to address workforce gaps and ensure the sector's sustainability and growth.

The nuclear sector is grappling with a significant proportion of its workforce nearing retirement age. Both reports emphasize the pressing need to replace a large number of retiring experts, particularly in critical roles such as nuclear engineers, scientists, and technical staff. The age distribution data indicate an increasing need for new recruits to maintain operational capabilities and uphold safety standards. There is a notable gap in specific nuclear-related skills and competencies. The demand for specialized roles such as project managers, radiation protection experts, and multidisciplinary professionals is high. This gap is exacerbated by the rapid technological advancements and evolving regulatory requirements in the nuclear sector.

Despite some improvements, there remains a disparity in gender representation, particularly in technical and engineering roles. Encouraging greater participation of women and underrepresented groups is essential for fostering a more diverse and inclusive workforce, which can contribute to enhanced innovation and problem-solving capabilities. The distribution of nuclear experts across different sectors has shifted, with an increase in roles related to design, engineering, manufacturing, and maintenance. Conversely, there has been a decrease in the proportion of experts in utility sectors. Additionally, the growing need for decommissioning expertise highlights a shift in the industry's focus and future requirements.

Both reports underscore the critical role of education and training in addressing HR needs.

Strengthening partnerships between industry and educational institutions, promoting STEM education, and establishing mentorship and internship programs are vital for developing a pipeline of skilled professionals. Continuous professional development and lifelong learning are also necessary to keep pace with industry changes. Implementing strategic workforce planning measures, such as National Nuclear Workforce Assessments (NWAs), can help map current workforce capabilities, predict future needs, and identify skills gaps. A coordinated approach at both national and EU levels is essential for effective workforce development and sustainability.

To address these challenges, it is essential to develop comprehensive nuclear skills strategies at national and EU levels, incorporating regular workforce assessments and strategic planning to address current and future HR needs. Increasing investment in education and training initiatives is crucial, focusing on creating tailored programs in collaboration with industry and educational providers. Targeted outreach efforts to attract new talent and promote careers in the nuclear sector are necessary. Implementing policies and initiatives to encourage greater participation of women and underrepresented groups and creating an inclusive work environment that values diverse perspectives and promotes equality are also important.

Developing retention strategies that offer competitive compensation, career development opportunities, and work-life balance initiatives will help retain skilled professionals. Supporting continuous learning and professional growth is vital for retaining talent. Facilitating job rotation and cross-functional training can enhance employee skillsets and career development, while encouraging mobility within the EU will help address regional disparities in workforce availability and demand.

Addressing the HR needs in the nuclear industry is paramount for maintaining the sector's operational efficiency, safety, and growth. By implementing strategic workforce planning, investing in education and training, fostering diversity and inclusion, and promoting retention and mobility, the EU can build a robust and skilled workforce capable of meeting the industry's future challenges. Collaborative efforts between industry, educational institutions, and policymakers are essential to achieve these goals and ensure the sustainable development of the nuclear sector.

There is a table that provides an analytical comparison of the findings from both reports. It highlights key aspects such as workforce aging, skills gaps, gender diversity, sectoral shifts, educational needs and strategic planning.

Table 3 Analytical comparison HR related aspects

Aspect	**Findings from "HR Needs in the Nuclear Industry"**	**Findings from "Supply and Demand for Nuclear Experts"**
Workforce Ageing	Significant portion nearing retirement, need for replacement	Aging workforce, need for new recruits to replace retirees
Skills Gaps	High demand for project managers, engineers, radiation protection experts	Notable gaps in specialized roles, multidisciplinary skills
Gender Diversity	Low female participation, need for inclusive policies	43% female nuclear experts, disparity in technical roles
Sectoral Shifts	Increased roles in design, engineering, manufacturing; decreased in utilities	Shift from utility sectors to design and manufacturing
Educational Needs	Need for strengthened partnerships, promotion of STEM, mentorship programs	Critical role of education, continuous professional development
Strategic Planning	Implementation of National Nuclear Workforce Assessments (NWAs), development of nuclear skills strategy	Need for regular workforce assessments, coordinated approach at EU level

2 COMPETENCE MAPPING: OVERVIEW AND METHODOLOGY

Competence mapping involves creating a detailed inventory of the skills, knowledge, and abilities (SKAs) required for various roles within an industry. This inventory is then used to benchmark current workforce capabilities against industry standards and future needs. The process begins with the identification of competences, determining the specific skills and knowledge areas critical for the nuclear industry. These competences range from technical skills such as reactor operation and safety protocols to soft skills like project management and communication.

Data collection follows, gathering information from various sources including surveys and interviews with industry professionals, academic institutions, and regulatory bodies. Additional data can be collected from job descriptions, training programs, and industry reports. Once the necessary competences are identified, the next step is competence assessment, which involves evaluating the current workforce's proficiency in these areas through self-assessments, performance reviews, and skills testing.

Gap analysis is then conducted by comparing current competences with those needed in the future to identify deficiencies. This analysis helps pinpoint areas where additional training and development are necessary. Based on this gap analysis, a strategic plan is developed to address the identified gaps. This plan includes specific Education and Training (E&T) initiatives, recruitment strategies, and partnerships with educational institutions to ensure the workforce is equipped to meet future industry demands.

Competence mapping serves as a foundational tool for various types of analysis in the nuclear industry. It can be used to:

Benchmarking: By comparing the competences of the current workforce against industry standards and international benchmarks, organizations can identify strengths and areas for improvement. This helps in maintaining competitive parity with global leaders in the nuclear sector.

Training and Development Planning: Competence mapping highlights the specific skills and knowledge areas that need enhancement. This information is crucial for designing targeted training programs and professional development initiatives that address the industry's needs.

Succession Planning: In an industry with an aging workforce, competence mapping helps identify critical roles and the skills required for these positions. This enables organizations to develop succession plans and ensure a smooth transition as experienced professionals retire.

Recruitment: By identifying the competences that are currently lacking, organizations can tailor their recruitment strategies to attract individuals with the necessary skills and knowledge. This ensures that new hires can immediately contribute to addressing identified gaps.

The process of competence mapping is integral to understanding the current capabilities and future needs of the nuclear industry workforce. By identifying, collecting, and assessing the required skills, knowledge, and abilities (SKAs), organizations can pinpoint specific areas where development is necessary. This detailed analysis provides a foundation for creating a structured taxonomy of competences, which categorizes these SKAs into a coherent framework. The taxonomy not only organizes competences into distinct categories but also facilitates targeted training and development initiatives. By linking the insights gained from competence mapping to a well-defined taxonomy, organizations can ensure that their workforce development efforts are both comprehensive and strategically aligned with industry needs.

Creating a taxonomy of competences involves categorizing the identified skills and knowledge areas into a structured framework. This taxonomy provides a clear and organized way to understand and communicate the various competences required in the nuclear industry. The taxonomy can be divided into several categories:

Table 4 Taxonomy of competences

Category	Competence Area	Description
Technical Competences	Nuclear Engineering	Skills related to the design, operation, and maintenance of nuclear reactors
Technical Competences	Radiation Protection	Knowledge of radiation safety standards, monitoring, and mitigation techniques
Technical Competences	Decommissioning	Expertise in safely dismantling nuclear facilities and managing radioactive waste
Scientific Competences	Nuclear Physics	Understanding of atomic and subatomic processes relevant to nuclear reactions
Scientific Competences	Materials Science	Knowledge of materials used in nuclear reactors, including their properties and behavior under radiation
Regulatory and Safety Competences	Regulatory Compliance	Familiarity with national and international nuclear regulations and standards
Regulatory and Safety Competences	Safety Management	Skills in implementing and managing safety protocols and emergency response procedures
Digital and Technological Competences	Digital Technologies	Proficiency in using digital tools and technologies such as AI, machine learning, and big data analytics in nuclear operations
Digital and Technological Competences	Cybersecurity	Knowledge of protecting nuclear facilities from cyber threats
Managerial and Soft Competences	Project Management	Skills in planning, executing, and overseeing nuclear projects
Managerial and Soft Competences	Communication	Ability to effectively communicate technical information to diverse stakeholders
Multidisciplinary Competences	Systems Engineering	Integration of various engineering disciplines to ensure the efficient and safe operation of nuclear systems
Multidisciplinary Competences	Environmental Science	Understanding the environmental impacts of nuclear energy and strategies for sustainable practices

Methodologies for Competence Mapping

Competence mapping is a critical process for identifying and assessing the skills, knowledge, and abilities required within an industry to meet current and future demands. In the nuclear industry, this process ensures that the workforce is adequately prepared to handle the complexities and safety requirements of nuclear operations. This report explores various methodologies for competence mapping in general, the specific methodologies currently used in the EU, and provides concrete examples of their utilization.
Competence mapping involves a systematic approach to understanding the current skill set within an organization and identifying the gaps that need to be filled to meet future operational requirements. In the nuclear industry, this is particularly crucial due to the high stakes involved in nuclear safety, technological advancements, and regulatory compliance. Ensuring that the workforce possesses the necessary competences not only mitigates risks but also enhances efficiency and innovation within the sector.

There are several methodologies for competence mapping, each with its unique approach and application. The following are some of the most widely used methodologies:

1. Job Analysis

This methodology involves a thorough examination of job roles to determine the specific competences required. It includes techniques such as interviews with incumbents, direct observation, and surveys. The data collected helps in creating comprehensive job descriptions and understanding the critical competences needed for various roles. This method is particularly effective in identifying the nuanced requirements of highly specialized positions within the nuclear sector.

2. Competence Frameworks

These frameworks provide a structured approach to defining competences across different levels and types within an organization. They categorize competences into technical, managerial, and soft skills, creating a benchmark for evaluating employee performance and identifying development needs. Competence frameworks are widely used in the nuclear industry to maintain high standards and ensure regulatory compliance.

3. 360-Degree Feedback

The 360-degree feedback method gathers competence-related feedback from multiple sources, including supervisors, peers, subordinates, and sometimes clients. This comprehensive approach provides a well-rounded view of an individual's competences and areas for improvement.

4. Skill Audits

Skill audits involve assessing the current skills of the workforce against the required competences. This method typically uses self-assessment questionnaires, skills testing, and performance reviews to identify gaps and training needs.

5. Task Analysis

Task analysis breaks down job roles into specific tasks and subtasks to determine the competences required for each. This method is particularly useful for technical and complex job roles, as it provides a detailed understanding of the necessary skills and knowledge.

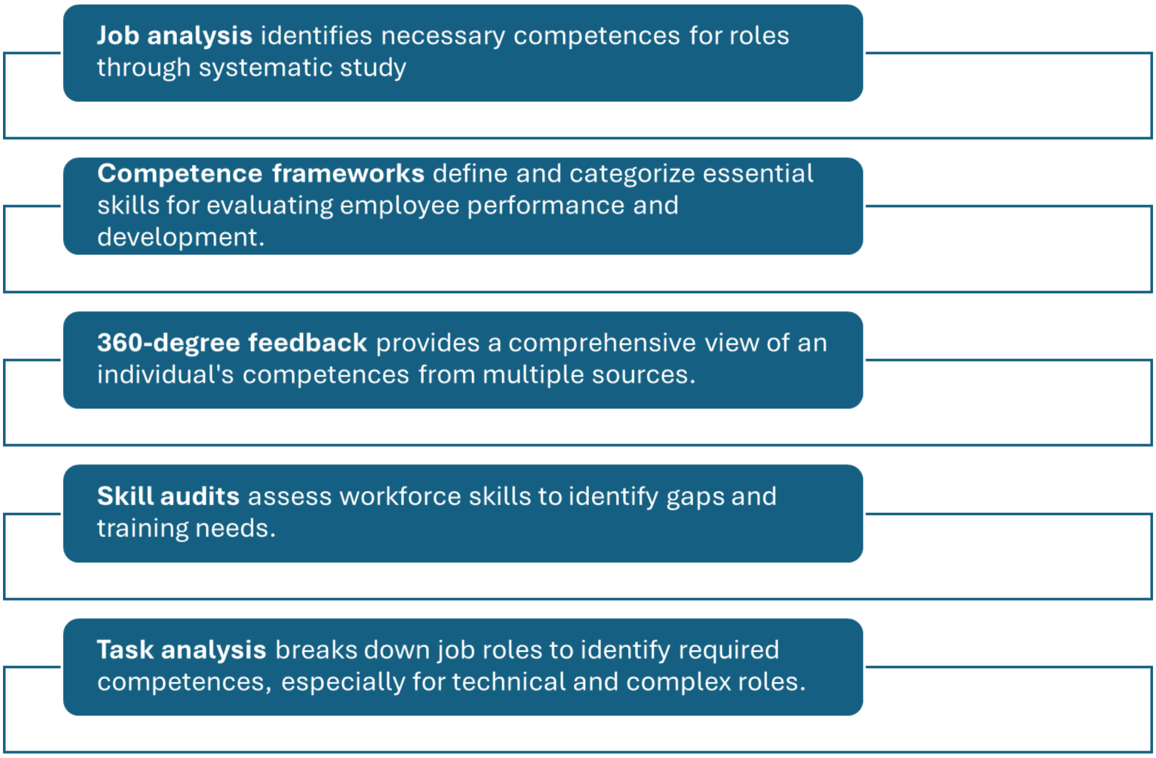

Figure 3: Methodologies for competence mapping

Methodologies for Competence Mapping Used in the EU

In the European Union, several methodologies are employed for competence mapping in the nuclear industry. These methodologies are often part of broader workforce development strategies aimed at ensuring the safety and efficiency of nuclear operations. The following are some of the key methodologies currently in use:

1. European Competence Framework (ECF)

The ECF is a comprehensive framework used across various sectors in the EU, including the nuclear industry. It defines competences at different levels and provides guidelines for assessing and developing these competences. The ECF helps in standardizing competence requirements across the EU and facilitates mobility and recognition of qualifications.

2. EURATOM Project Assessments

The EURATOM projects often include competence mapping as part of their workforce development activities. These projects use a combination of job analysis, skill audits, and task analysis to identify competence gaps and develop targeted training programs. For example, the EURATOM FP7 project aimed at enhancing the training and education of nuclear professionals through competence mapping and tailored curricula.

3. National Workforce Assessments

Several EU member states conduct national workforce assessments to map competences in the nuclear sector. These assessments involve extensive data collection through surveys, interviews, and workshops with industry stakeholders. The results help in identifying national competence gaps and informing policy and training initiatives.

There are several examples of such a methodologies utilisation.

British Energy Estimation Model (BEEM)

The UK uses the British Energy Estimation Model (BEEM) to map competences in the nuclear industry. BEEM combines job analysis and skill audits to assess the current workforce and predict future competence needs. This model has been instrumental in developing training programs and informing recruitment strategies in the UK nuclear sector.

Joint Research Centre (JRC) Initiatives

The European Commission's Joint Research Centre (JRC) conducts competence mapping as part of its research and training activities. The JRC uses task analysis and competence frameworks to identify skill gaps and develop training modules for nuclear professionals. For instance, the JRC's involvement in the EHRO-N project includes competence mapping to support the development of a nuclear energy management school.

Finnish National Competence Survey

Finland's nuclear industry conducted a national competence survey to map the skills and knowledge of its workforce. This survey used a combination of self-assessment questionnaires and 360-degree feedback to gather data on competences. The findings informed the development of national training programs and workforce policies aimed at addressing identified gaps.

OECD-NEA NEST Initiative

The Nuclear Education, Skills and Technology (NEST) initiative by the OECD-NEA is another example of competence mapping in practice. The NEST initiative uses job analysis and competence frameworks to identify critical competences needed for emerging nuclear technologies, such as SMRs. This initiative supports international collaboration and competence building through targeted training and educational programs.

Competence mapping is an essential process for ensuring that the nuclear industry has the necessary skills and knowledge to operate safely and efficiently. Various methodologies, including job analysis, competence frameworks, 360-degree feedback, skill audits, and task analysis, provide comprehensive approaches to identifying and addressing competence gaps. In the EU, these methodologies are applied through frameworks like the ECF, EURATOM project assessments and national workforce assessments. Concrete examples illustrate the practical application and benefits of competence mapping in the nuclear industry. By leveraging these methodologies the EU can continue to develop a skilled and competent nuclear workforce capable of meeting future challenges.

3 REFERENCES

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ANNEX 1 EXAMPLES OF CURRICULA OF EDUCATIONAL PROGRAMS FROM VARIOUS EU COUNTRIES

Belgium-KU Leuven

Master of Nuclear Engineering (Leuven et al) (60 ECTS)

Master of Science

Admission requirements 2023-2024

Admission requirements 2022-2023

Programme

Schedule

Stage1

Reset

Expand

This group contains all courses. Students are required to take all courses offered.

Compulsory Courses

Students are required to take all courses.

3 ECTS	Nuclear Energy: Introduction	H02G2A
3 ECTS	Introduction to nuclear physics and measurements	H02G3A
3 ECTS	Radiation protection	H02H1B
6 ECTS	Nuclear reactor theory and experiments	H02G4B
5 ECTS	Nuclear Thermal Hydraulics	H02G5B
5 ECTS	Safety of Nuclear Power Plants	H0S27A
3 ECTS	Nuclear Fuel Cycle	H02G8A
3 ECTS	Nuclear Materials	H02G9A

Elective Courses

Students are required to choose three courses from the list below.

3 ECTS	Advanced Nuclear Reactor Physics and Technology	H0S28A
3 ECTS	Advanced Nuclear Materials	H0S29A
3 ECTS	Advanced Radiation Protection/ Radiation Ecology	H0S30A
3 ECTS	Advanced Courses of the Nuclear Fuel Cycle	H0S31A
3 ECTS	Nuclear and Radiological Risk Governance	H0S32A
3 ECTS	Advanced Course Elective Topic	H02H2B

Master's Thesis

20 ECTS	Master's Thesis	H02H3B

Romania-Master level

Nr. *No.*	Denumirea disciplinei *Subject*	[3]Total ore *Number of hours*		Nota *Grade*		Număr de credite *Number of ECTS / SECT credits*	
		C	S, LP, P	Sem I *1st sem*	Sem II *2nd sem*	Sem I *1st sem*	Sem II *2nd sem*
Anul I (anul universitar 2016/2017) *1st year of study (2016/2017 academic year)*							
1.	**Analiză matematică** *Mathematical analysis*	28	28,-,-	8	-	5	-
2.	**Algebră liniară, geometrie analitică şi diferenţială** *Linear algebra, analytical and differential geometry*	28	28,-,-	7	-	4	-
3.	**Geometrie descriptivă şi desen tehnic** *Descriptive geometry and technical drawing*	14	-,28,-	10	-	3	-
4.	**Informatică aplicată** *Applied informatics*	14	-,28,-	9	-	3	-
5.	**Fizică (1)** *Physics (1)*	28	-,14,-	10	-	4	-
6.	**Chimie** *Chemistry*	28	-,14,-	10	-	3	-
7.	**Tehnologia materialelor** *Materials technology*	28	-,14,-	10	-	3	-
8.	**Limba străină 1** *Foreign language 1*	-	28,-,-	10	-	2	-
9.	**Instituţii europene şi administraţie europeană** *European institutions and European administration*	28	14,-,-	10	-	3	-
10.	**Matematici speciale** *Advanced mathematics*	28	28,-,-	-	7	-	4
11.	**Ecuaţii diferenţiale şi statistică matematică** *Differential equations and mathematical statistics*	28	28,-,-	-	9	-	5
12.	**Grafică asistată de calculator** *Computer-aided design*	14	-,28,-	-	9	-	3
13.	**Fizică (2)** *Physics (2)*	28	-,14,-	-	7	-	3
14.	**Programarea calculatoarelor** *Computer programming*	14	-,28,-	-	8	-	3
15.	**Comunicare profesională** *Professional communication*	28	14,-,-	-	9	-	3
16.	**Mecanică** *Mechanics*	28	-,14,-	-	8	-	3
17.	**Economie** *Economics*	28	14,-,-	-	8	-	3
18.	**Educaţie fizică şi sport (2)** *Physical education and sport (2)*	-	28,-,-	-	10	-	3
Promovat cu media:[4] *Pass, average grade per academic year:* 8.83		Total credite: *Total ECTS / SECT credits:* 60					
Anul II (anul universitar 2017/2018) *2nd year of study (2017/2018 academic year)*							
1.	**Bazele electrotehnicii 1** *Fundamentals of electrotechnique 1*	28	14,-,-	5	-	5	-
2.	**Bazele termodinamicii tehnice 1** *Fundamentals of technical thermodynamics 1*	28	14,14,-	7	-	5	-
3.	**Mecanica fluidelor 1** *Fluid mechanics 1*	28	-,14,-	6	-	4	-
4.	**Rezistenţa materialelor** *Strength of materials*	28	42,-,-	9	-	4	-
5.	**Electronică** *Electronics*	28	-,14,-	9	-	3	-
6.	**Energetică generală** *Fundamentals of energy engineering*	28	14,-,-	10	-	3	-
7.	**Dezvoltare durabilă** *Sustainable development*	28	14,-,-	10	-	3	-

Nr. *No.*	Denumirea disciplinei *Subject*	3)Total ore *Number of hours*		Nota *Grade*		Număr de credite *Number of ECTS / SECT credits*	
		C	S, LP, P	Sem I *1st sem*	Sem II *2nd sem*	Sem I *1st sem*	Sem II *2nd sem*
8.	**Resurse financiare şi analiză economică** *Financial resources and economic analysis*	14	28,-,-	9	-	3	-
9.	**Metode numerice** *Numerical methods*	28	-,28,-	-	9	-	4
10.	**Bazele electrotehnicii 2** *Fundamentals of electrotechnique 2*	28	14,14,-	-	9	-	4
11.	**Bazele termodinamicii tehnice 2** *Fundamentals of technical thermodynamics 2*	28	14,-,-	-	6	-	4
12.	**Mecanica fluidelor 2** *Fluid mechanics 2*	28	14,14,-	-	7	-	4
13.	**Transfer de căldură şi masă** *Heat and mass transfer*	28	28,14,-	-	7	-	5
14.	**Mecanisme şi organe de maşini** *Mechanisms and mechanical components*	28	28,-,-	-	10	-	4
15.	**Utilizarea energiei apelor** *Water energy use*	28	-,14,-	-	10	-	3
16.	**Sociologia şi psihologia muncii** *Sociology and labor psychology*	28	-,-,-	-	10	-	2
Promovat cu media:4) *Pass, average grade per academic year:*	8.31	Total credite: *Total ECTS / SECT credits:*		60			
Anul III (anul universitar 2018/2019) *3rd year of study (2018/2019 academic year)*							
1.	**Măsurarea mărimilor electrice** *Measuring electrical quantities*	28	-,28,-	10	-	4	-
2.	**Maşini şi acţionări electrice** *Electrical machines and drive systems*	28	-,28,-	10	-	4	-
3.	**Echipamente şi instalaţii termice** *Thermal equipments and installations*	28	-,14,14	9	-	5	-
4.	**Echipamente electrice** *Electrical equipments*	28	-,14,-	10	-	3	-
5.	**Maşini hidraulice** *Hydraulic machinery*	28	-,28,-	10	-	5	-
6.	**Teoria reglării automate** *Automatic control theory*	28	-,14,-	9	-	3	-
7.	**Energia şi mediul** *Energy and environment*	28	14,-,-	8	-	3	-
8.	**Măsurarea mărimilor neelectrice** *Measuring non-electrical quantities*	28	-,28,-	9	-	3	-
9.	**Bazele teoriei reactoarelor nucleare** *Fundamentals of nuclear reactors theory*	42	-,-,28	-	10	-	5
10.	**Dozimetrie şi radioprotecţie** *Dosimetry and radiation protection*	28	-,14,-	-	10	-	3
11.	**Turbomaşini** *Turbomachinery*	42	-,14,-	-	8	-	4
12.	**Utilizarea energiei** *Energy use*	28	-,14,-	-	10	-	3
13.	**Producerea energiei electrice şi termice** *Electrical and thermal power generation*	28	-,28,-	-	10	-	3
14.	**Partea electrică a centralelor şi staţiilor** *Electrical part of power plants and substations*	28	-,28,-	-	9	-	3
15.	**Reţele electrice** *Electrical grids*	28	-,14,14	-	10	-	3
16.	**Practică** *Internship*	-	-,360,-	-	10	-	6
Promovat cu media:4) *Pass, average grade per academic year:*	9.50	Total credite: *Total ECTS / SECT credits:*		60			

Nr. *No.*	Denumirea disciplinei *Subject*	3)Total ore *Number of hours*	Nota *Grade*	Număr de credite *Number of*

						ECTS / SECT credits	
		C	S, LP, P	Sem I *1st sem*	Sem II *2nd sem*	Sem I *1st sem*	Sem II *2nd sem*
Anul IV (anul universitar 2019/2020) *4th year of study (2019/2020 academic year)*							
1.	**Fiabilitate** *Reliability*	28	-,14,-	9	-	3	-
2.	**Drept şi legislaţie în energetică** *Law and legislation in energy*	28	-,-,-	10	-	3	-
3.	**Centrale nuclearo-electrice** *Nuclear power plants*	42	-,-,28	8	-	5	-
4.	**Termohidraulica instalaţiilor nucleare** *Thermal-hydraulic nuclear installations*	42	-,14,14	10	-	4	-
5.	**Materiale şi tehnologii nucleare** *Nuclear materials and technologies*	42	-,28,-	10	-	5	-
6.	**Cinetica şi dinamica reactoarelor nucleare** *Kinetics and dynamics of nuclear reactors*	28	-,14,-	10	-	4	-
7.	**Studiu pentru elaborarea proiectului de diplomă 1** *Study to elaborate the diploma project 1*	-	-,-,28	10	-	3	-
8.	**Transportul agenţilor energetici** *Transport of technological fluids*	28	-,14,-	8	-	3	-
9.	**Ingineria şi tehnologia reactoarelor nucleare** *Engineering and technology of nuclear reactors*	42	-,-,28	-	10	-	6
10.	**Management în energetică** *Management in energy*	28	-,14,-	-	10	-	3
11.	**Sisteme în centralele nuclearo-electrice** *Systems in nuclear power plants*	42	-,14,14	-	9	-	5
12.	**Acţionări hidropneumatice** *Fluid power drives*	28	-,14,-	-	9	-	3
13.	**Studiu pentru elaborarea proiectului de diplomă 2** *Study to elaborate the diploma project 2*	-	-,-,112	-	10	-	8
14.	**Tehnologii nucleare nonenergetice** *Non-energy nuclear technology*	28	-,-,28	-	10	-	5
Promovat cu media:[4)] *Pass, average grade per academic year:* 9.50		Total credite: *Total ECTS / SECT credits:* 60					

Italy – Politecnico di Milano (Master level)

1st Year courses

Track ENN - Energetica

Campus: Milano Bovisa

Track offered in Italian

Code	Act type	SSD	Course Title	Language	Type	Sem	CFU	CFU Group
081360	A	MAT/03 MAT/05	CALCULUS 1 *Students form A to BOM - Grasselli Maurizio* *Students form BOM to CES - Muratori Matteo* *Students form CES to E - Hochenegger Andreas* *Students form E to GOZ - Munarini Emanuele* *Students form GOZ to MARF - Frigeri Achille* *Students form MARF to P - Potrich Norman* *Students form P to RAZ - Cipriani Fabio Eugenio Giovanni* *Students form RAZ to STR - Lantaria Federico Giampiero* *Students form STR to ZZZZ - Notari Roberto*	IT	M	1	10.0	10.0
081369	A	ING-INF/05	INFORMATICS B *Students form A to CAN - Di Nitto Elisabetta* *Students form CAN to E - Santambrogio Marco Domenico* *Students form E to LEM - Terraneo Federico* *Students form LEM to P - Trovo' Francesco* *Students form P to SAM - Masseroli Marco* *Students form SAM to ZZZZ - Marchesi Alberto*	IT	M	1	7.0	7.0
081374	A	CHIM/07	CHEMISTRY *Students form A to BOM - Cametti Massimo* *Students form BOM to CES - Gambarotti Cristian* *Students form CES to E - Raos Guido* *Students form E to GOZ - Canalegno Mose'* *Students form GOZ to MARF - Cavallo Gabriella* *Students form MARF to P - Marti Rujas Javier* *Students form P to RAZ - Pizzi Andrea* *Students form RAZ to STR - Ganazzoli Fabio* *Students form STR to ZZZZ - Famulari Antonino*	IT	M	1	7.0	7.0
081376	B	ING-IND/15	METHODS OF TECHNICAL REPRESENTATION *Students form A to BOM - Colombo Giorgio* *Students form BOM to CES - Caruso Giandomenico* *Students form CES to E - Becattini Niccolo'* *Students form E to GOZ - Cascini Gaetano* *Students form GOZ to MARF - Graziosi Serena* *Students form MARF to P - Ferrise Francesco* *Students form P to RAZ - Vigano' Roberto* *Students form RAZ to STR - Girotti Ambrogio Luigi* *Students form STR to ZZZZ - Bertola Paolo*	IT	M	1	7.0	7.0
052431	A	MAT/03 MAT/05	CALCULUS 2 *Students form A to BOM - Compagnoni Marco* *Students form BOM to CES - Ceratti Maria Cristina* *Students form CES to E - Gumenyuk Pavel* *Students form E to GOZ - Schlesinger Enrico Ettore Marcello* *Students form GOZ to MARF - Borrelli William* *Students form MARF to P - Citterio Maurizio Giovanni* *Students form P to RAZ - Vegni Federico Mario Giovanni* *Students form RAZ to STR - Stanesi Francesca* *Students form STR to ZZZZ - Boella Marco Ugo Claudio*	IT	M	2	10.0 [1.0 [illegible]]	10.0
081389	A	FIS/01	FUNDAMENTALS OF EXPERIMENTAL PHYSICS *Students form A to BOM* *- 081386 FUNDAMENTALS OF EXPERIMENTAL PHYSICS (I) - Dal Conte Stefano* *- 081387 FUNDAMENTALS OF EXPERIMENTAL PHYSICS (B) - Dal Conte Stefano* *Students form BOM to CES* *- 081386 FUNDAMENTALS OF EXPERIMENTAL PHYSICS (I) - Spinelli Lorenzo* *- 081387 FUNDAMENTALS OF EXPERIMENTAL PHYSICS (B) - Spinelli Lorenzo* *Students form CES to E* *- 081386 FUNDAMENTALS OF EXPERIMENTAL PHYSICS (I) - Crepaldi Alberto* *- 081387 FUNDAMENTALS OF EXPERIMENTAL PHYSICS (B) - Reduzzi Maurizio Battista* *Students form E to GOZ* *- 081386 FUNDAMENTALS OF EXPERIMENTAL PHYSICS (I) - Frigerio Jacopo* *- 081387 FUNDAMENTALS OF EXPERIMENTAL PHYSICS (B) - Frigerio Jacopo* *Students form GOZ to MARF* *- 081386 FUNDAMENTALS OF EXPERIMENTAL PHYSICS (I) - Di Sieno Laura* *- 081387 FUNDAMENTALS OF EXPERIMENTAL PHYSICS (B) - Di Sieno Laura* *Students form MARF to P* *- 081386 FUNDAMENTALS OF EXPERIMENTAL PHYSICS (I) - Gadermaier Christoph* *- 081387 FUNDAMENTALS OF EXPERIMENTAL PHYSICS (B) - Gadermaier Christoph* *Students form P to RAZ* *- 081386 FUNDAMENTALS OF EXPERIMENTAL PHYSICS (I) - Ferragut Rafael Omar* *- 081387 FUNDAMENTALS OF EXPERIMENTAL PHYSICS (B) - Candeo Alessia* *Students form RAZ to STR* *- 081386 FUNDAMENTALS OF EXPERIMENTAL PHYSICS (I) - Isella Giovanni* *- 081387 FUNDAMENTALS OF EXPERIMENTAL PHYSICS (B) - Chrastina Daniel* *Students form STR to ZZZZ* *- 081386 FUNDAMENTALS OF EXPERIMENTAL PHYSICS (I) - Folegati Paola* *- 081387 FUNDAMENTALS OF EXPERIMENTAL PHYSICS (B) - Folegati Paola*	IT	I	2	12.0	12.0
081377	B	ING-IND/21	METALLURGY AND NON METALLIC MATERIALS *Students form A to CAN - Gariboldi Elisabetta* *Students form CAN to E - Barella Silvia* *Students form E to LEM - D'Errico Fabrizio* *Students form LEM to P - Castrodeza Enrique Mariano* *Students form P to SAM - Lecis Nora Francesca Maria* *Students form SAM to ZZZZ - Boniardi Marco Virginio*	IT	M	2	7.0	7.0

2nd Year courses

Track ENN - Energetica

Campus: Milano Bovisa

Track offered in Italian

Code	Act type	SSD	Course Title	Language	Type	Sem	CFU	CFU Group
094847	B	ING-IND/13	FUNDAMENTALS OF MECHANICS *Students form A to M - Tomasini Gisella Marita* *Students form M to ZZZZ - Di Gialleonardo Egidio*	IT	M	1	8.0	8.0
094848	C	ICAR/08	MECHANICS OF SOLIDS *Students form A to M - Pandolfi Anna Marina* *Students form M to ZZZZ - Ardito Raffaele*	IT	M	1	8.0	8.0
094849	C	ICAR/01	FLUID MECHANICS *Students form A to M - Guadagnini Alberto* *Students form M to ZZZZ - Siena Martina*	IT	M	1	8.0	8.0
095042	A,C	MAT/06 SECS-S/01	STATISTICS *Students form A to M - Guglielmi Alessandra* *Students form M to ZZZZ - Toigo Alessandro*	IT	M	1	6.0	6.0
054058	A	FIS/03	WAVES AND OPTICS *Students form A to ZZZZ - Zavelani Rossi Margherita*	IT	M	1	6.0	
083795	B	ING-IND/10	THERMODYNAMICS AND HEAT TRANSFER *Students form A to M - Niro Alfonso* *Students form M to ZZZZ - Colombo Luigi Pietro Maria*	IT	M	2	10.0	10.0
083720	C	ING-IND/17 ING-IND/35	FUNDAMENTALS OF MANAGEMENT AND INDUSTRIAL ENGINEERING *Students form A to M* *- 083718 FUNDAMENTALS OF MANAGEMENT AND INDUSTRIAL ENGINEERING - Trucco Paolo* *- 083719 FUNDAMENTALS OF MANAGEMENT AND INDUSTRIAL ENGINEERING - Dell'Agostino Laura* *Students form M to ZZZZ* *- 083718 FUNDAMENTALS OF MANAGEMENT AND INDUSTRIAL ENGINEERING - Miragliotta Giovanni* *- 083719 FUNDAMENTALS OF MANAGEMENT AND INDUSTRIAL ENGINEERING - Manfredi Latilla Vito Maria*	IT	I	2	10.0	10.0
097336	B	ING-IND/31 ING-IND/33	POWER SYSTEM FUNDAMENTALS *Students form A to M - Merlo Marco* *Students form M to ZZZZ - Leva Sonia*	IT	M	2	10.0	10.0

Track E3N - Ingegneria Nucleare

Campus: Milano Bovisa

Track offered in Italian

Code	Act type	SSD	Course Title	Language	Type	Sem	CFU	CFU Group
090856	B	ING-IND/08	HYDRAULIC AND THERMAL MACHINERY *Students form A to ZZZZ - Montenegro Gianluca*	IT	M	1	10.0	10.0
054647	B	ING-IND/19	INTRODUCTION TO NUCLEAR ENGINEERING A+B *Students form A to ZZZZ - Ricotti Marco Enrico*	EN	M	1	10.0 [2.0]	10.0
093808	B	ING-IND/19	RADIOACTIVITY AND RADIATION PROTECTION (C.I.) *Students form A to ZZZZ* *- 093807 RADIATION PROTECTION (MODULO C.I.) - Campi Fabrizio* *- 093806 RADIOACTIVITY (MODULO C.I.) - Pola Andrea*	IT	I	1	10.0	10.0
072574	B	ING-IND/09	ENERGY SYSTEMS AND ENVIRONMENTAL IMPACT *Students form A to ZZZZ - Lozza Giovanni Gustavo*	IT	M	2	10.0	10.0
086214	A	MAT/05 MAT/08	ANALYTICAL AND NUMERICAL METHODS FOR ENGINEERING *Students form A to ZZZZ* *- 086213 ANALYTICAL AND NUMERICAL METHODS (SECTION NUMERICAL METHODS) - Scotti Anna* *- 086212 ANALYTICAL AND NUMERICAL METHODS (SECTION ANALYSIS) - Cerutti Maria Cristina*	IT	I	2	10.0	10.0
052346	B	ING-IND/12 ING-IND/19	MEASUREMENTS AND ELECTRONICS FOR INDUSTRIAL APPLICATIONS *Students form A to ZZZZ - Fazzi Alberto*	IT	M	2	5.0	5.0
052343	B	ING-IND/19	LABORATORY OF NUCLEAR ENGINEERING [a] *Students form A to ZZZZ - Lorenzi Stefano*	IT	V	2	5.0 [3.0]	5.0

052344	B	ING-IND/12	MEASUREMENT LAB FOR ENERGY ENGINEERING [b] *Students form A to ZZZZ - Sala Remo*	IT	V	2	5.0 [3.0]	
052345	B	ING-IND/09 ING-IND/31	MICROGRIDS LABORATORY [c] *Students form A to ZZZZ - Di Marcoberardino Gioele*	IT	V	2	5.0 [3.0]	

(a) Closed number subject
(b) Closed number subject
(c) Closed number subject

1st Year courses

Track X2A - NUCLEAR ENGINEERING

Campus: Milano Bovisa

Track offered in English

Code	Act type	SSD	Course Title	Language	Type	Sem	CFU	CFU Group
--	--	--	Courses to be chosen from Group TABLE LM NUC1	--	--	--	--	20.0
052591	B	ING-IND/20	RADIATION DETECTION AND MEASUREMENT *Students form A to ZZZZ - Caresana Marco*	EN	M	1	10.0 [2.0]	10.0
055620	B	ING-IND/18	FISSION REACTOR PHYSICS 1 *Students form A to ZZZZ - Cammi Antonio*	EN	M	2	10.0	10.0
054649	B	ING-IND/19	RELIABILITY, SAFETY AND RISK ANALYSIS A+B *Students form A to ZZZZ - Baraldi Piero*	EN	M	2	10.0 [1.0]	10.0
089473	C	FIS/03	SOLID STATE PHYSICS (a) *Students form A to ZZZZ - Li Bassi Andrea*	EN	M	2	10.0	
085888	C	FIS/03	SOLID STATE PHYSICS (b) *Students form A to ZZZZ - Dellasega David*	IT	M	2	10.0	
057919	B,C	ING-IND/20 ING-INF/01	ADVANCED DETECTION SYSTEMS FOR NUCLEAR TECHNOLOGIES I + II *Students form A to ZZZZ* *- 057918 ADVANCED DETECTION SYSTEMS FOR NUCLEAR TECHNOLOGIES II - Bortot Davide* *- 057917 ADVANCED DETECTION SYSTEMS FOR NUCLEAR TECHNOLOGIES I - Fazzi Alberto*	EN	I	2	10.0	
057920	B	ING-IND/20	APPLIED RADIOCHEMISTRY A+B *Students form A to ZZZZ - Mariani Mario*	IT	M	2	10.0 [2.0]	10.0
057925	B,C	FIS/03 ING-IND/18	PHYSICS OF NUCLEAR MATERIALS + NUCLEAR TECHNIQUES FOR THE ANALYSIS OF MATERIALS *Students form A to ZZZZ - Beghi Marco*	EN	M	A	10.0 [1.0]	
053354	B	ING-IND/19	ARTIFICIAL INTELLIGENCE AND ADVANCED SIMULATION FOR THE SAFETY, RELIABILITY AND MAINTENANCE OF ENERGY SYSTEMS *Students form A to ZZZZ - Di Maio Francesco*	EN	M	1	10.0 [3.0]	

(a) Closed number subject
(b) Closed number subject

2nd Year courses

Track X2B - Nuclear Plants

Campus: Milano Bovisa

Track offered in English

Code	Act type	SSD	Course Title	Language	Type	Sem	CFU	CFU Group
057922	B	ING-IND/19	NUCLEAR DESIGN AND TECHNOLOGY *Students form A to ZZZZ - Luzzi Lelio*	EN	M	1	10.0 [3.0]	10.0
097675	B	ING-IND/18	FISSION REACTOR PHYSICS II *Students form A to ZZZZ - Giacobbo Francesca Celsa*	EN	M	1	5.0	10.0
097680	B	ING-IND/18	TRANSPORT OF RADIOACTIVE CONTAMINANTS *Students form A to ZZZZ - Giacobbo Francesca Celsa*	EN	M	2	5.0	
052594	B	ING-IND/19	EXPERIMENTAL NUCLEAR REACTOR KINETICS *Students form A to ZZZZ - Lorenzi Stefano*	EN	M	1	5.0 [5.0]	
097731	B	ING-IND/19	INTERNAL CONTAMINATION + APPLIED RADIATION PROTECTION *Students form A to ZZZZ* *- 097728 INTERNAL CONTAMINATION - Porta Alessandro Antonio* *- 097727 APPLIED RADIATION PROTECTION - Porta Alessandro Antonio*	IT	I	2	10.0	10.0
053354	B	ING-IND/19	ARTIFICIAL INTELLIGENCE AND ADVANCED SIMULATION FOR THE SAFETY, RELIABILITY AND MAINTENANCE OF ENERGY SYSTEMS *Students form A to ZZZZ - Di Maio Francesco*	EN	M	1	10.0 [3.0]	
054649	B	ING-IND/19	RELIABILITY, SAFETY AND RISK ANALYSIS A+B *Students form A to ZZZZ - Baraldi Piero*	EN	M	2	10.0 [1.0]	
057920	B	ING-IND/20	APPLIED RADIOCHEMISTRY A+B *Students form A to ZZZZ - Mariani Mario*	IT	M	2	10.0 [2.0]	
056243	B	ING-IND/10	MULTIPHASE SYSTEMS AND TECHNOLOGIES +CFD FOR NUCLEAR ENGINEERING *Students form A to ZZZZ* *- 056242 CFD FOR NUCLEAR ENGINEERING - Besagni Giorgio* *- 056241 MULTIPHASE SYSTEMS AND TECHNOLOGIES - Colombo Luigi Pietro Maria*	EN	I	1	10.0	
--	--	--	Courses to be chosen from Group LM NUC 2A	--	--	--	--	15.0
--	--	--	Courses to be chosen from Group LM NUC 2B	--	--	--	--	
--	--	--	Courses to be chosen from Group LM NUC 2C	--	--	--	--	
--	--	--	Courses to be chosen from Group LM NUC 2D	--	--	--	--	
--	--	--	Courses to be chosen from Group LM NUC 2E	--	--	--	--	
097721	--	--	THESIS WORK *Students form -- to --- - Docente non definito*	EN	V	1	15.0	15.0
097721	--	--	THESIS WORK *Students form -- to --- - Docente non definito*	EN	V	2	15.0	

Track X2C - Nuclear Technologies

Campus: Milano Bovisa

Track offered in English

Code	Act type	SSD	Course Title	Language	Type	Sem	CFU	CFU Group
057922	B	ING-IND/19	NUCLEAR DESIGN AND TECHNOLOGY *Students form A to ZZZZ - Luzzi Lelio*	EN	M	1	10.0 [3.0]	10.0
097564	B	ING-IND/20	MEDICAL APPLICATIONS OF RADIATION FIELDS *Students form A to ZZZZ - Giulini Castiglioni Agosteo Stefano Luigi Maria*	EN	M	1	10.0	10.0
097731	B	ING-IND/19	INTERNAL CONTAMINATION + APPLIED RADIATION PROTECTION *Students form A to ZZZZ* *- 097728 INTERNAL CONTAMINATION - Porta Alessandro Antonio* *- 097727 APPLIED RADIATION PROTECTION - Porta Alessandro Antonio*	IT	I	2	10.0	
057920	B	ING-IND/20	APPLIED RADIOCHEMISTRY A+B *Students form A to ZZZZ - Mariani Mario*	IT	M	2	10.0 [2.0]	10.0
097731	B	ING-IND/19	INTERNAL CONTAMINATION + APPLIED RADIATION PROTECTION *Students form A to ZZZZ* *- 097728 INTERNAL CONTAMINATION - Porta Alessandro Antonio* *- 097727 APPLIED RADIATION PROTECTION - Porta Alessandro Antonio*	IT	I	2	10.0	

057919	B,C	ING-IND/20 ING-INF/01	ADVANCED DETECTION SYSTEMS FOR NUCLEAR TECHNOLOGIES I + II *Students form A to ZZZZ* *- 057918 ADVANCED DETECTION SYSTEMS FOR NUCLEAR TECHNOLOGIES II - Bortot Davide* *- 057917 ADVANCED DETECTION SYSTEMS FOR NUCLEAR TECHNOLOGIES I - Fazzi Alberto*	EN	I	2	10.0	
052645	B,C	FIS/03 ING-IND/18	HIGH INTENSITY LASERS FOR NUCLEAR AND PHYSICAL APPLICATIONS I+II *Students form A to ZZZZ - Zavelani Rossi Margherita*	EN	M	A	10.0	
051426	B	ING-IND/18	FISSION REACTOR PHYSICS II + TRANSPORT OF RADIOACTIVE CONTAMINANTS *Students form A to ZZZZ - Giacobbo Francesca Celsa*	EN	M	A	10.0	
--	--	--	Courses to be chosen from Group LM NUC 2A	--	--	--	--	15.0
--	--	--	Courses to be chosen from Group LM NUC 2B	--	--	--	--	
--	--	--	Courses to be chosen from Group LM NUC 2C	--	--	--	--	
--	--	--	Courses to be chosen from Group LM NUC 2D	--	--	--	--	
--	--	--	Courses to be chosen from Group LM NUC 2E	--	--	--	--	
097721	--	--	THESIS WORK *Students form -- to -- - Docente non definito*	EN	V	1	15.0	15.0
097721	--	--	THESIS WORK *Students form -- to -- - Docente non definito*	EN	V	2	15.0	

Track X2D - Nuclear Systems Physics

Campus: Milano Bovisa

Track offered in English

Code	Act type	SSD	Course Title	Language	Type	Sem	CFU	CFU Group
057922	B	ING-IND/19	NUCLEAR DESIGN AND TECHNOLOGY *Students form A to ZZZZ - Luzzi Lelio*	EN	M	1	10.0 [3.0]	10.0
097564	B	ING-IND/20	MEDICAL APPLICATIONS OF RADIATION FIELDS *Students form A to ZZZZ - Giulini Castiglioni Agosteo Stefano Luigi Maria*	EN	M	1	10.0	10.0
052645	B,C	FIS/03 ING-IND/18	HIGH INTENSITY LASERS FOR NUCLEAR AND PHYSICAL APPLICATIONS I+II *Students form A to ZZZZ - Zavelani Rossi Margherita*	EN	M	A	10.0	
097609	C	FIS/03	PLASMA PHYSICS I+II *Students form A to ZZZZ - Passoni Matteo*	EN	M	1	10.0	10.0
097716	C	FIS/03	PHYSICS OF NUCLEAR MATERIALS + PHYSICS OF DISORDERED MATERIALS *Students form A to ZZZZ* *- 097691 PHYSICS OF DISORDERED MATERIALS - Ossi Paolo Maria* *Students form A to ZZZZ* *- 097689 PHYSICS OF NUCLEAR MATERIALS - Docente non definito*	EN	I	1	10.0	
051426	B	ING-IND/18	FISSION REACTOR PHYSICS II + TRANSPORT OF RADIOACTIVE CONTAMINANTS *Students form A to ZZZZ - Giacobbo Francesca Celsa*	EN	M	A	10.0	
097621	C	FIS/03	STATISTICAL PHYSICS *Students form A to ZZZZ - Piazza Roberto*	EN	M	1	10.0	
--	--	--	Courses to be chosen from Group LM NUC 2A	--	--	--	--	15.0
--	--	--	Courses to be chosen from Group LM NUC 2B	--	--	--	--	
--	--	--	Courses to be chosen from Group LM NUC 2C	--	--	--	--	
--	--	--	Courses to be chosen from Group LM NUC 2D	--	--	--	--	
--	--	--	Courses to be chosen from Group LM NUC 2E	--	--	--	--	
097721	--	--	THESIS WORK *Students form -- to -- - Docente non definito*	EN	V	1	15.0	15.0
097721	--	--	THESIS WORK *Students form -- to -- - Docente non definito*	EN	V	2	15.0	

Czech Republic – Master level

Master´s Degree Program

Nuclear Engineering

Specialization Applied Physics of Ionizing Radiation 1st year

Course	code	lecturer	win. sem.	sum. sem.	cr	cr
Compulsory courses:						
Quantum Physics	02KFM	Jizba	2+1 z, zk	-	3	-
Nuclear Safety	17JABE	Frýbortová, Sklenka	4+0 zk	-	5	-
Research Project 1, 2	16VUJI12	Trojek	0+6 z	0+8 kz	6	8
Advanced Experimental Neutron Physics	17PENF	Huml	-	1+3 kz	-	4
Advanced Topics in Nuclear and Radiation Physics	16PPJRF	Musílek, Urban	2+1 z, zk	-	3	-
Instrumentation for Radiation Measurements	16MERV	Průša	2+2 z, zk	-	4	-
Practicum in Detection and Dosimetry of Ionizing Radiation	16PDZNMS	Martinčík, Průša	0+4 kz	-	4	-
Accelerators in Medicine and Technology	16UMT	Augsten	1+0 kz	-	1	-
Monte Carlo Method in Radiation Physics	16MCRF	Klusoň, Urban	-	2+2 z, zk	-	4
Ionizing Radiation in the Environment	16IZZP	Štěpán, Vrba T.	-	2+1 z, zk	-	3
Integral Dosimetry Methods	16IDOZ	Ambrožová, Musílek	-	2+0 zk	-	2
Methods of Analytical Measurement	16AMMN	Pilařová, Průšová	-	2+0 kz	-	2
Excursion	16EX	Thinová	-	1 týden z	-	2
Optional courses:						
Radiation Effects in Matter	16REL	Pilařová	2+0 zk	-	2	-
Treatment of Experimental Data	16ZED	Pilařová	-	2+0 zk	-	2
Monte Carlo Method	18MEMC	Jarý, Virius	2+2 z, zk	-	4	-
Radiation Protection	16RAO	Vrba T.	4+0 zk	-	4	-
Practicum in Dosimetry of Ionizing Radiation	16PDIZ	Štěpán	-	0+4 kz	-	4
Digital Image Processing	01DIZO	Flusser, Zitová	-	2+2 zk	-	4
Fundamentals of clinical dosimetry	16ZKLD	Čechák, Hanušová, Novotný J.	-	2+0 zk	-	2

Nuclear Engineering

Specialization Applied Physics of Ionizing Radiation 2nd year

Course	code	lecturer	win. sem.	sum. sem.	cr	cr
Compulsory courses:						
Metrology of Ionizing Radiation	16MEIZ	Novotný P., Trojek	2+1 z, zk	-	4	-
Applications of lonizing Radiation 1	16APIZ1	Čechák, Trojek	3+0 zk	-	3	-
Master Thesis 1, 2	16DPJI12	Trojek	0+10 z	0+20 z	10	20
Applications of lonizing Radiation 2	17APIZ2	Miglierini, Štefánik	-	2+1 z, zk	-	3
Spectrometry in Dosimetry	16SPD	Čechák, Novotný P.	2+0 zk	-	2	-
Mathematical Methods and Modelling	16MMM	Klusoň, Urban	0+2 z	-	2	-
Medical Application of Ionizing Radiation	16AIZM	Hanušová, Jelínek-Michaelidesová	2+1 z, zk	-	3	-
Microdosimetry	16MDOZI	Jelínek-Michaelidesová, Pachnerová-Brabcová	2+0 kz	-	2	-
Overview of Elementary Particle Physics	16PFE	Smolík	2+0 kz	-	2	-
Seminar 2	16SEM2	Pilařová	-	0+2 z	-	2
Optional courses:						
Neutron Dosimetry	16DNEU	Ploc	2+0 zk	-	2	-
Clinical Dosimetry	16KLD2	Hanušová, Novotný J., Trojek	2+0 kz	-	2	-
Image Processing and Pattern Recognition 2	01ROZP2	Flusser	2+1 zk	-	4	-
Dosimetry of Internal Radiation Sources	16DZAR	Musílek	-	2+0 zk	-	2
Radiobiology	16RBIO	Davídková	-	2+0 zk	-	2
Introduction into Physics of Scintillators and Phosphors	16FSC	Nikl	-	2+0 zk	-	2
Design of Semiconductor Detectors of Ionizing Radiation	16KPD	Kákona	-	0+3 z	-	3
Start-up Project	01SUP	Rubeš	2+0 kz	-	2	-

LISTS

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