TECHNOLOGIES FOR NUCLEAR ENERGY STATE OWNED COMPANY

INSTITUTE FOR NUCLEAR RESEARCH

RA-TEN ICN PITEŞTI

INSTITUTUL DE CERCETĂRI NUCLEARE

2022

ANNUAL REPORT

www.nuclear.ro

Technologies for Nuclear Energy State Owned Company
Institute for Nuclear Research Pitesti Subsidiary

RATEN ICN

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This document was drafted according to Appendix 6 of the Memorandum of the Ministry for Public Consultation and Civic Dialogue *"Increasing transparency and standardization in the display of public interest information"*.

*The editorial staff of the **Annual Report of RATEN ICN for 2022** gives thanks for the good collaboration to all program managers, project managers and heads of departments*

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ABOUT RATEN ICN

Identification data

Name: **Technologies for Nuclear Energy State Owned Company - Institute for Nuclear Research Pitesti Subsidiary (RATEN ICN)**

Registration number at the Trade Register Office: **J3/1316/2013**

Sole Registration Number (CUI): **RO32306920**

Headquarters: **Arges County, Mioveni; Câmpului Street No. 1**

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Filed of activity: **CAEN 7219**

SHORT PRESENTATION

The **Institute for Nuclear Research Pitesti** was founded in 1971 as a unit of strategic importance, having as field of activity scientific research, design, technological engineering and scientific and technical responsibility for the development of nuclear energy in Romania.

The history of the 50 years of activity has recorded a series of successive transformations generated by the development of the national economy and the adaptation of the nuclear objectives to the new requirements of society, with the following milestones in time:

1971	It was set up the Institute for Nuclear Technologies (ITN) subordinated to the State Committee for Nuclear Energy (CSEN);
1977	ITN becomes the Institute for Nuclear Energy Reactors (IRNE);
1990	The Institute for Nuclear Energy Reactors (IRNE) is included in the National Authority for Electricity (RENEL) and becomes the Institute for Nuclear Research (ICN);
1992	The Fuel Elements Production Department (SPEC) within ICN becomes distinct economic unit within RENEL, as the Nuclear Fuel Plant (FCN);
1998	ICN is included in the Romanian Authority for Nuclear Activities (RAAN) as subsidiary becoming RAAN-Nuclear Research Branch, according to GD 365/1998
2013	**Starting 1st October**, *the Institute for Nuclear Research Pitesti (ICN) becomes a subsidiary of the State Owned Company "Technologies for Nuclear Energy (RATEN)",* established under Emergency Ordinance no. 54 from 29th May 2013, approved by Law no. 302/2013.
2020	Starting with January 17, RATEN ICN was designated "International Centre based on Research Reactor – ICERR" for the fields of "Education and Training" and "Joint Research and Development (R&D) Projects";
2021	**ICN celebrated 50 years since its establishment as a scientific and technical support organization for the Romanian nuclear program.**

Organizational structure

The structure of the research activity of the Institute is harmonized with the national and international research programs in the nuclear field. The organizational chart of the institute is structured on sections, laboratories, services, offices, consisting of research and development departments, technical departments, production, maintenance-repair and administrative departments.

- Department of Reactor Physics, Nuclear Fuel Performance and Nuclear Safety
- TRIGA Reactor Department
- Nuclear Materials and Corrosion Department
- Out of Pile Testing Department
- Radioactive Waste Treatment and Conditioning Plant
- Electronics Department
- Post-Irradiation Examination Laboratory (PIEL)
- Surface Analysis Laboratory
- Reliability and Testing Laboratory
- Radiation Protection, Environmental Protection and Civil Protection
- Metrology & IT Laboratory
- Quality Technical Control Laboratory
- Design Department.
- Nuclear Prototypes Workshop
- Quality Management Office
- Utilities Production and Distribution Department
- Repairs, Maintenance, Chief Mechanic Department

Support Deparments (Programs, Contracts; Foreign Relations, Technology Transfer, Protocol; Administration, Human Resources, Financing, Accountancy; Procurement, Marketing; Investments, Heritage; Emergency Situations, Prevention and Protection; Legal; Transport; Medical, Toxicology, Analysis; Physical Protection; Safeguards; Protection of Classified Information).

Scope

The Institute for Nuclear Research Pitesti (RATEN ICN) has as main object of activity scientific research, technological development with fundamental and applicative character, capitalization of own research through technology transfer, design, investments, consultancy, expertise and specialized technical assistance, subordinated to ensuring scientific and technical support for the nuclear energy field in Romania.

The research, development and innovation departments of the institute include activities oriented towards the following objectives:

- *Providing scientific and technical support for the Cernavoda Nuclear Power Plant (NPP) throughout its lifetime;*
- *Carrying out research and development activities necessary for the sustainable development of the National Nuclear Energy Program;*
- *Development of competences in nuclear materials and fuels, reactor physics, nuclear safety, equipment, instrumentation and control for nuclear applications, management, characterization and treatment of radioactive waste, environmental protection and radiation protection;*
- *Development of infrastructure, scientific research capacity and technology transfer and innovation services;*
- *Conducting the international collaboration program to increase expertise, competitiveness and alignment of RATEN ICN with policies specific to the European Union by developing the capacity to assimilate and apply advanced techniques and technologies;*
- *Ensuring human resources in the field of research activities by stimulating professional training and development of research capacity of young people.*

Through its activity, the institute contributes to fulfilling the government's responsibility for energy security, nuclear safety, radioactive waste security, non-proliferation, safety of radioactive sources and prevention of terrorism.

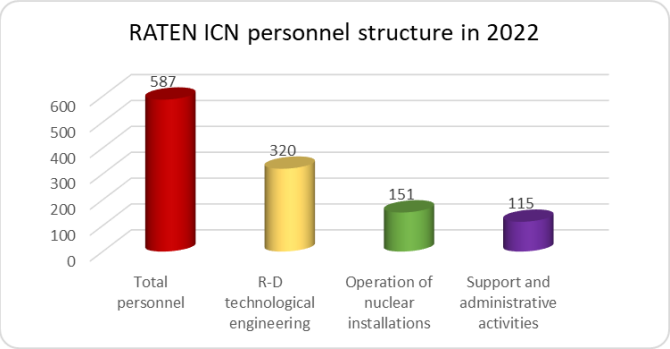
RATEN ICN provides services in the fields of:
- Reactor physics, nuclear fuel performance and nuclear safety;
- Irradiation, radioisotope tests, post-irradiation examination of materials and nuclear fuel;
- Testing outside the reactor;
- Testing of nuclear materials under thermo-mechanical and corrosion conditions, compatible with those in operation;
- Management of radioactive waste;
- Qualification tests and tests for nuclear equipment, components and equipment;
- Radiation protection, environmental protection;
- Design of nuclear equipment.

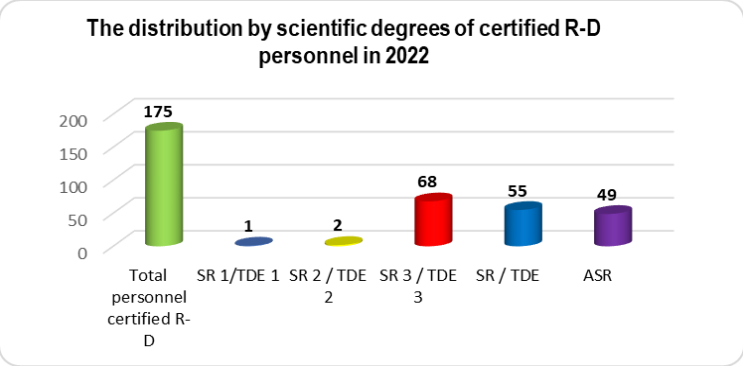
RATEN ICN also promotes the development and application of nuclear technologies in medicine, industry or agriculture, adding an important contribution to raising the standard of living for the benefit of citizens.

The main technologies developed by RATEN ICN include:
- technologies for manufacturing experimental fuel elements and advanced nuclear fuels;
- technologies for obtaining UO_2 sinterable powders and UO_2 sintered pills with controlled microstructure;
- technologies for testing nuclear fuel and materials;
- technologies for manufacturing targets for obtaining radioactive sources;
- technologies for working with closed sources;
- radioisotope production technologies with applications in health, environment or industry;
- technologies and equipment for testing, commissioning, inspection, maintenance and repair of components in nuclear installations;tehnologii pentru mentenanţa echipamentelor din CNE;
- technologies and testing systems outside the reactor;
- technologies for treatment, conditioning and characterization of radioactive waste from CNE and other research and development activities in the nuclear field;
- technologies for decontamination of components and equipment in nuclear power plants

Human resources

In 2022, the total number of employees within RATEN ICN Pitesti was 587, of which 320 work in research and development and technological engineering, 151 ensure the operation of nuclear installations while 115 employees provide technical and administrative support for the optimal development of R&D activities as well as ensuring the safe operation of the platform (ensuring utilities for RATEN, RATEN ICN, FCN and ANDR Piteşti).





In the Institute there are 175 certified researchers, specialists with a high level of training in engineering, physics, chemistry and other fields, authorized by CNCAN, ISCIR, etc.

Most of the specialists in the institute have followed post-graduate training, masters, doctorates or specialization courses conducted in the country or abroad, working as experts of the International Atomic Energy Agency (IAEA) or in international research programs.

The knowledge accumulated during the years of training is reflected in the large number of works carried out within research programs, national and international projects.

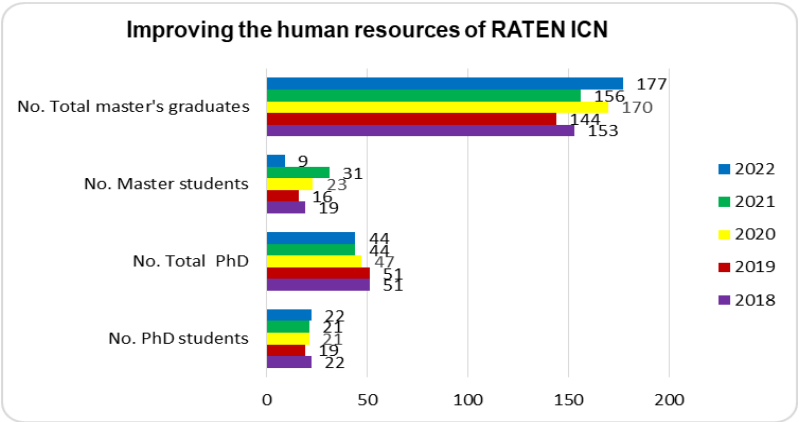
In 2022, RATEN ICN personnel followed specific annual training programs in the field of nuclear safety, radiation protection and environmental protection, protection of classified information, quality management, environment, occupational health and safety, followed by evaluation and testing stages. At the same time, RATEN ICN researchers and specialists had the opportunity to participate in courses / seminars organized by RATEN ICN (8 actions, number of participants: 21), national training courses (11 courses, number of participants - 21, online: 3, number of participants - 6), or at international level (17 actions (online: 5), number of participants - 18).

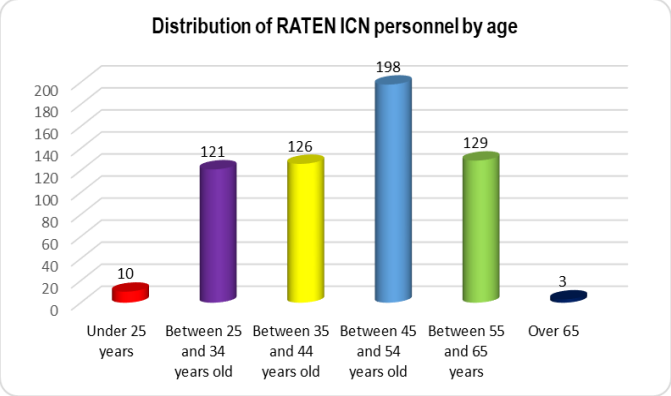
Also, during 2022, a number of **9 employees attended master's studies** organized by the **University of Pitesti**, in the fields of:

- Nuclear Materials and Technologies;
- Power Engineering and Nuclear Technologies;
- Industrial engineering;
- Electronic systems for conducting industrial processes.

A number of 22 employees participated in doctoral studies. They were organized by the University of Pitesti, University Politehnica of Bucharest, University of Craiova and Valahia University Targoviste, in the fields of:

- Electronic Engineering and Telecommunications;
- Applied Chemistry and Materials Science;
- Power engineering;
- Electrical engineering;
- Economics;
- Nuclear engineering;
- Materials engineering;
- Cybernetics and statistics





From the adjacent graph, it can be seen that majority of employees are aged between 45 and 54, closely followed by those aged between 55 and 65, and some of them are close to retirement age. The average age in RATEN ICN is 43 years and 7 months for women while for men it is 46 years and 1 month. The number of certified researchers has decreased in the last year due to the retirement of leading specialists. Under these circumstances, there is a risk of losing the knowledge acquired in this top field.

In recent years, due to the systematic employment of young specialists in research departments, the personnel structure of RATEN ICN has improved by increasing the number of employees with higher education. In 2022, a number of 37 people were employed, of which 24 with higher education and 13 workers.

The experimental installations and the experience gained by the specialists of the institute ensure the support of the active involvement of young people in national, European and international programs and projects.

The competences acquired by experienced researchers in the institute, nationally and internationally, can be harnessed by transferring knowledge to new employees or students from higher education institutions who practice in RATEN ICN.

The transfer of knowledge between generations is one of the main challenges of the nuclear field in the near future. In order to understand the technological processes, the training programs include visits to the main objectives, nuclear installations and laboratories of the institute: TRIGA Reactor, Post-Irradiation Examination Laboratory, Nuclear Materials and Corrosion Departments, Testing Stand Outside the Reactor, Radioactive Waste Treatment Plant, Testing and Reliability Laboratory, Radiation Protection, Environmental Protection and Civil Protection Laboratory.

Within the strategy of human resources and technology transfer, actions have been carried out to promote the institute's activity in high schools and universities aimed at attracting young people to jobs specific to the nuclear field. Thus, RATEN ICN participated on December 8, 2022, in the science fair, educational offers and jobs "With small, with big ..... Through the Universe" dedicated to pupils and students interested in educational and professional activities in the field of Science, Technology, Engineering and Mathematics (STEM in English terminology), but also to the teachers who prepare them. They came into contact with educational program providers and important employers in the fields of industry, research and high-class technologies on the Romanian market. The event was organized on the Magurele platform, by the Faculty of Physics of the University of Bucharest (FF-UB), the National Institute of Physics and Nuclear Engineering – Horia Hulubei (IFIN- HH), the Student Association of the University of Bucharest (ASF-UB) and the Science Education Community (CEST). At this event, RATEN ICN representatives participated with the presentation entitled "RATEN ICN – Options for a scientific career", which touched on the following elements: RATEN ICN mission, research infrastructure, R&D activities and priority projects as well as human resource challenges. At the same time, brochures related to ALFRED's infrastructure were distributed.

The event "With small, with big... through the Universe", Faculty of Physics, Magurele, December 8, 2022

Also in 2022, RATEN ICN honored its obligations assumed through the partnership agreements concluded with higher education institutions, such as the University of Pitesti, the Polytechnic University of Bucharest, the Mansoura University, through which it offered students training internships for the completion of bachelor's theses, master's or practical training. Thus, 26 students in their final years and 14 master's students at UPIT, UPB and Mansoura University, Egypt benefited from guidance from RATEN ICN specialists for the completion of their undergraduate and dissertation works.

The COVID-19 pandemic affected both the organization and the physical participation in the anticipated forms of preparation for 2022. For this reason, the actions planned for the transfer of knowledge and the promotion of RATEN

ICN's image could be organized through physical participation starting from a second part of the year by organizing scientific, documentary or informative visits to the institute in which 161 people participated.

Infrastructure

RATEN ICN owns the following research infrastructure: [https://nuclear.ro/infrastructura/]

- Reactorul Nuclear de Cercetare TRIGA SSR 14 MW şi TRIGA ACPR;
- Post-Irradiation Examination Laboratories (LEPI);
- other capacities and laboratories specific to the field, namely:
  - Radioactive Waste Treatment Station (STDR);
  - Test Stand Outside the Reactor (TAR);
  - Laboratory for the Analysis and Diagnosis of Corroded Components in Nuclear Installations (LADICON);
  - Testing Laboratory for the Characterization of Spent Nuclear Fuel and Radioactive Waste (LABORAD);
  - Laboratory of Radiochemistry and Radiometry of Radioactive Waste (LRRDR)
  - Surface Analysis Laboratory (ESCALAB);
  - Laboratory of Radioprotection, Environmental Protection and Civil Protection (LRMPPC);
  - Testing and Reliability Laboratory (LIF);
  - Technical Quality Control Laboratory (CTC);
  - Laboratory of Metrology and Information Technology.

This material base is characterized by diversity, performance and reliability, the high level of nuclear safety of the installations in operation being recognized by the national and international regulatory and control organizations, the National Commission for the Control of Nuclear Activities (CNCAN) and the International Atomic Energy Agency (IAEA) Vienna.

In 2017, RATEN ICN's research infrastructure and related research services were registered on the ERRIS platform (Engage in the Romanian Research Infrastructures System) () (https://erris.gov.ro/REGIA-AUTONOM-TEHNOLOGII-PEN-1) for the designation of Installations and Special Objectives of National Interest (IOSIN).

RATEN ICN requested the designation of 3 installations as Installations and Special Objectives of National Interest (IOSIN) [http://www.research.gov.ro/uploads/iin/2018/rezultate-evaluare-iosin-2018.pdf], with a positive result following the assessment by the Ministry of Research and Innovation of the submitted requests, as follows:
- The TRIGA reactor and the Post Irradiation Examination Laboratory (LEPI) - 84 points
- Radioactive Waste Treatment Station (STDR) - 79 points
- Nuclear Fuel Loading/Unloading Machine Test Stand (MID) in CANDU Reactors - 71 points

ECONOMIC AND FINANCIAL SITUATION

RATEN ICN's main activity of research and development, applications and technological engineering, related to national technical support and international cooperation, funded according to GEO 144/1999, is carried out within the RATEN Annual Research Program on Development of national technical support and international cooperation for nuclear energy.

In detail, the breakdown of expenses of the RATEN ICN 2022 Annual Research Programme is as follows:

Programme	Denomination	Performer	Scheduled papers		Completed papers	
			No.	Value (lei)	No.	Value (lei)
1	Nuclear safety	RATEN ICN	21	3,400,000.00	21	3,400,000.00
2	Fuel channel	RATEN ICN	20	3,050,000.00	20	3,050,000.00
3	Nuclear fuels	RATEN ICN	22	3,900,000.00	22	3,900,000.00
4	Fuel handling system	RATEN ICN	16	4,313,980.00	16	4,313,980.00
5	Management of radioactive waste and spent fuel under nuclear safety conditions	RATEN ICN	26	9,600,000.00	26	9,600,000.00
6	Environmental protection	RATEN ICN	23	6,200,000.00	23	6,200,000.00
7	Steam generator	RATEN ICN	8	1,750,000.00	8	1,750,000.00
8	Process Systems and Equipment	RATEN ICN	7	1,700,000.00	7	1,700,000.00
9	Chemistry circuits	RATEN ICN	11	2,900,000.00	11	2,900,000.00
10	Instrumentation and control	RATEN ICN	19	3,300,000.00	19	3,300,000.00
11	Analysis of NPP operating events, aging, environmental qualification and increase of NPP service life	RATEN ICN	15	4,046,740.00	15	4,046,740.00
12	Advanced nuclear reactors and fuel cycles	RATEN ICN	30	5,750,000.00	30	5,750,000.00
13	Ensuring and increasing the performance of the TRIGA-ICN reactor	RATEN ICN	49	30,600,000.00	49	30,600,000.00
14	Irradiation and radioisotope technologies	RATEN ICN	7	1,500,000.00	7	1,500,000.00
15	Informatization nuclear activities	RATEN ICN	5	890,000.00	5	890,000.00
16	Heavy water and tritium	RATEN ICN	3	990,215.00	3	990,215.00
17	Applications of nuclear techniques	RATEN ICN	5	722,370.00	5	722,370.00
18	International cooperation	RATEN ICN	12	3,617,695.00	12	3,617,695.00
TOTAL RATEN ICN PITESTI			**300**	**88,231,000**	**300**	**88,231,000**

In 2022, RATEN ICN Pitesti had ongoing service contracts in the field of nuclear energy and design services concluded with SNN-CNE Cernavoda, SNN-FCN Pitesti and other internal and external customers, as follows:

- Annual Research Program 2022, which provides national technical support for nuclear energy, Ministry of Energy;
- Contracts concluded with SNN-FCN Piteşti for:

- *Technical assistance and monitoring services for ICSI Rm. Valcea*
- *Environmental monitoring services*
- *Uranium and beryllium concentration determination services in urine*
- *Laboratory chemical analysis services*
- *Treatment services of radioactive solid waste*
- *Service contract and utilities supply (heating agent and industrial water)*
- *Treatment services for radioactive water from the production activities of FCN Pitesti Branch*
- *Chip compaction services of Zircaloy-4 (Zy-4) and assembly of resulting briquettes*

- *Study on compliance with NSN21 and the classification of CNE and FCN personnel in radiological risk categories, beneficiary: Ernst&Young Romania*
- *Update of the contaminated area study Dumbravita, beneficiary: OMV PETROM SA*
- *Post-irradiation examination services of spent nuclear fuel beams, discharged from Cernavoda NPP reactors*
- *Environmental radiological impact assessment services for CTRF installation, Danube Delta INCD Tulcea*
- *Analyzes for determining radioactive indicators from samples of natural mineral water, SN Ape Mineral SA*
- *Sample analysis services in order to establish the radiochemical level C14 and Sr 90 alpha / betaglobal and transuranic elements, SNN – Cernavoda NPP*
- *Personnel training courses for radioactive waste characterization activities, SC Nuclearelectrica Serv. SRL*
- *Services of takeover, transport and treatment as radioactive waste of a source, County Emergency Service « Sf Ioan Suceava, INSP Bucharest*
- *Services of taking over and transporting radioactive material for storage under control, Insolvency expert Judicial liquidator and NITROPOROS SRL Fagaras*
- *Service for taking over and transporting nuclear materials, Bucharest insolvency expert, SC INDAGRA PRODCOM SA, in bankruptcy*
- *Take-over services 1459 fire detectors type DIC, Cos Targoviste SA*
- *Services of takeover, transport, intermediate storage of GDPU5 and GDPU2 installation, CE OLTENIA SA Tg. Jiu, SC OVITIM CND AG SRL*
- *Services for takeover, conditioning, treatment and final storage of closed and open sources, INSP Bucharest*
- *Metallographic and fractographic analysis services to identify the cause and determine the valve failure mechanism 2-4323-V624, SNN – Cernavoda NPP*
- *Refurbishment of GFPU1 and GFPU2 systems, SNN Cernavoda NPP*
- *Equipment refreshing services at RATEN ICN Pitesti, SANDIA*
- *Autoclaving tests in water at supercritical temperatures on stainless steel samples 316L, National Institute for Research and Development for Laser, Plasma and Radiation Physics - INFLPR Magurele*
- *Maintenance services for air sampling stations type CAS 1 (National Institute for Research and Development for Cryogenic and Isotopic Technologies – ICSI Rm. Valcea)*
- *Metrological verification/calibration services dosimetric equipment (SC TOTAL GAZ INDUSTRIES SRL, PETROCONST SA, OMV PETROM SA, SC EXPROTERM SRL, PETROM)*
- *Sensor finding and detection service, PETROCONST SA*
- *Service contract (utilities supply), ANDR, SNN-FCN Pitesti, REINVENT ENERGY*
- *Services for demineralized water delivery, SC Eurotehnic IND SRL Pitesti, SC ALRO SA Slatina*
- *Production and delivery of sources*

57 closed sources of 192Ir, with a total activity of 2558 Ci, were produced and delivered to the following beneficiaries: RAC Navodari, CONDMAG Braşov, MOLDOCOR Neamţ, ENERGOMONTAJ Rovinari, WELD MILDIN CND Bascov, CND CONTROL Cluj, IMUC Piteşti, ARGENTA SRL, TUV Austria, NUCLEAR NDT R&S Bucharest, MONTICOR Ploieşti, DYOMEDICA Ploieşti, SNC Constanţa, WALTER TOSTO Bucharest, PETROCONST Constanta, EUROGLOBAL Sibiu, MECANPETROL Gaesti, COMPCONTROL ING Ploieşti, COMOSERV Oneşti, EXPROTERM Suceava, TOTAL GAZ Iasi, EURO GAS SYSTEMS TG. Mures, CSD Constanta, VARD Tulcea, SOCEND Rovinari,

ENERGOUTIL CONTACT Bucharest, NONDESTRUCTIVE GALATI, DELGAZ GRID TG. Mureş, NDT TESTING Odobeşti, EUROGLOBAL Sibiu.

- Verification of industrial gammagraphy installation type SENTINEL

25 checks were performed at SENTINEL 880 installations for 11 companies: SC NUCLEAR NDT RESEARCH & SERVICES SRL, Bucharest, SC CND CONTROL SRL, Cluj – Napoca; SC WELD MILDIN CND SRL, Bascov; SC NDT TESTING SRL, Odobeşti, Vrancea; SC EXPROTERM SRL, Suceava; SC TOTAL GAZ INDUSTRIE SRL, Iasi; SHIPYARD Constanta SA; SC WALTER TOSTO WTB SRL, Bucharest; SC EURO GAS SYSTEMS SRL, Targu-Mures; SC COMPCONTROL ING SRL, Ploiesti; SC COMOSERV SRL Oneşti.

The institute's income in 2022 was ensured through:

- *National Research and Development Programs for Nuclear Energy financed by the Ministry of Energy;*
- *Research projects within the European Union Research Programmes (Horizon 2020 and Horizon Europe) and with the International Atomic Energy Agency (IAEA Vienna);*
- *Economic contracts with various partners in the country.*

Market and customers		**Percent from total income**
1. The main collaboration on the foreign market	European Community	6,71
2. Main customers on the domestic market	S.N.N.	81.45%
	I.N.C.D. Delta Dunării	1.65%
	COS Târgovişte	1.24%
	A.N.D.R.	0.99%
	CLIENTS from sales iridium sources, SENTINEL installation checks and other economic contracts: COMPCONTROL ING, MONTICOR INDUSTRIES SA, NUCLEAR NDT RESEARCH AND SERVICES, OMV PETROM, RAC NAVODARI, NATIONAL SOCIETY OF MINERAL WATERS, WALTER TOSTO WTB ETC.	7.96%
	TOTAL	**100**

RATEN ICN OBJECTIVES AND ACHIEVEMENTS IN 2022

Scientific activity

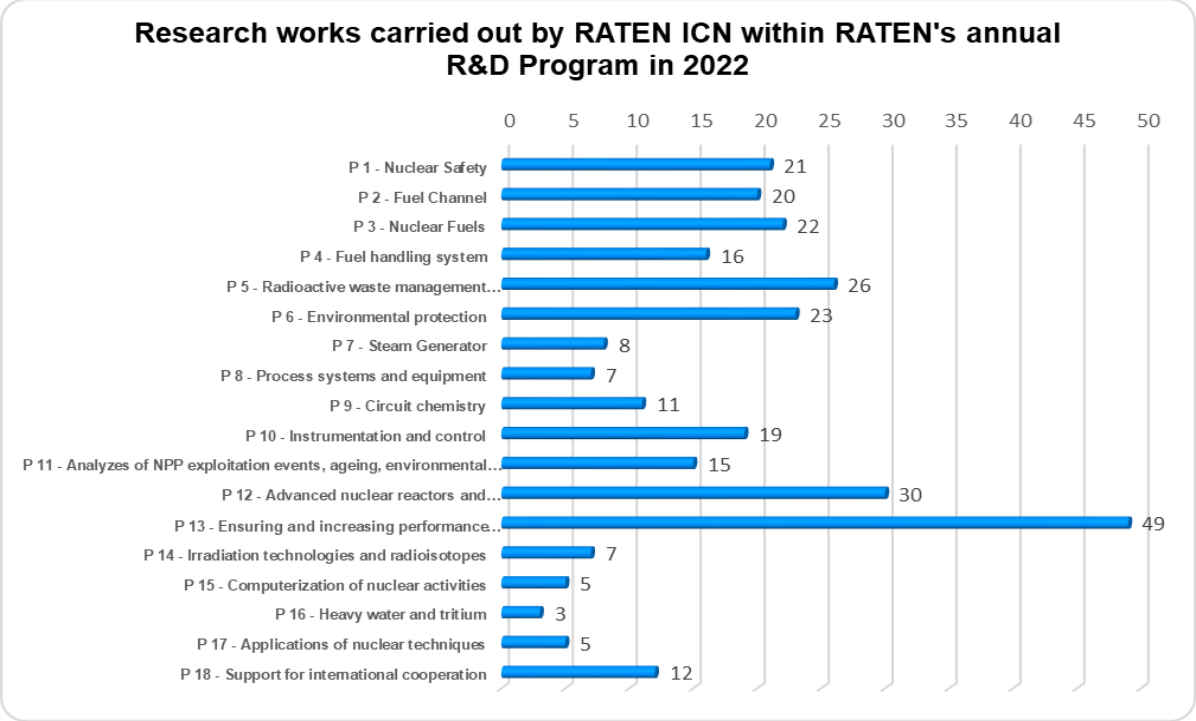
The annual program of RATEN ICN Pitesti includes 18 research-development programs and is carried out in accordance with the objectives of the Strategic Research-Development Program of the Technologies for Nuclear Energy State Owned Company regarding the development of national technical support and international cooperation for nuclear energy.

P1	Nuclear safety
P2	Fuel Channel
P3	Nuclear Fuels
P4	Fuel handling system
P5	Radioactive waste and spent fuel management in nuclear safety conditions
P6	Environment protection
P7	Steam generator
P8	Process systems and equipment
P9	Circuit chemistry
P10	Instrumentation and control
P11	Analysis of NPP operating events, aging, environmental qualification and increasing operating lifetime
P12	Advanced nuclear reactors and fuel cycles
P13	Ensuring and increasing the performance of the TRIGA ICN reactor
P14	Irradiation and radioisotope technologies
P15	Computerization of nuclear activities
P16	Heavy water and tritium
P17	Applications of nuclear techniques
P18	International cooperation

In 2022, within the 18 programs, 300 research works were carried out in the form of Internal Reports. These materialized in studies, technologies, calculation programs, analysis methods, models, prototypes, products, projects, company standards, nuclear safety documentation, reports, etc.
The objectives of the CDIT Programs, elaborated in accordance with the RATEN Development Strategy 2015 – 2025, the priorities at national and international level, the international agreements and treaties in the field of nuclear energy to which Romania is a party, were oriented towards:

- The safe operation and nuclear safety of Units 1 and 2 at CNE-Cernavodă and the extension of their lifetime;
- The development of skills and services regarding the economical and predictable operation of the fuel channels in the CANDU reactor at CNE Cernavodă, based on experimental and theoretical investigations and the results of periodic inspections;
- Contributions to the commissioning of Units 3 and 4, based on the experience gained;
- Implementation of the experience and practice of CANDU power plant operators, by applying the CANDU Owners Group (COG)-Canada Research Programs to Cernavodă Units 1 and 2, improving the technical and scientific support provided to CNE-Cernavodă by increasing the contribution to the realization of these programs.
- The 2022 CDIT programs were structured on research themes, within which the actual research works were carried out. The research topics are proposed depending on the national and international research priorities, the international agreements, conventions and treaties to which Romania is a party, under the conditions of the peaceful use of nuclear energy, in correlation with the objectives and strategic directions of action of the Strategy RATEN Research-Development 2015-2025.

The number of elaborated works, associated with each research-development and technological engineering program is shown in the following diagram:



For this purpose, theoretical studies, mathematical modeling were carried out, calculation codes were run, experimental tests and tests were performed on structural, fissile or irradiated nuclear materials, experimental fuel elements were made, specific technologies for radioactive waste management and storage were developed and applied, advanced IV generation reactors were promoted in the medium and long term, the critical infrastructure was operated in nuclear safety and security conditions (TRIGA Research Reactor, Post-Irradiation Examination Laboratory, Radioactive Waste Treatment Plant), continued the activity of education and training of specialists in the field, as well as promotion of international cooperation. In this sense, the support activities for the promotion and preparation of projects dedicated to the development of lead-cooled fast reactors, the ALFRED project, as well as the research and development works within the FALCON consortium are mentioned.

International Cooperation

RATEN's participation in international research programs is a priority of the international collaboration program, supported this year as well by ensuring the necessary support to achieve the objectives assumed by RATEN ICN specialists in ongoing projects, as well as maintaining an active presence within the EURATOM Framework Program of the European Commission, the IAEA Technical Cooperation program, but also the NEA/OECD Collaboration Program.

Collaboration with the European Union

RATEN's participation in the Euratom Framework Programme is a priority of the international collaboration programme and has been supported by providing the necessary support to achieve the objectives assumed by RATEN ICN specialists in ongoing projects and in-kind projects proposed within various European structures dedicated to the nuclear field.

This year, the activities foreseen within the ongoing projects EURAD, PIACE, PATRICIA, ECC-SMART, PASCAL, ORIENT NM and PREDIS were carried out. Following the Horizon Europe competition in 2022, the following projects were approved for funding and launched: ANSELMUS, ENEN2plus, HARMONISE, HARPERS, INNUMAT, FREDMANS, ECOSENS and SASPAM-SA.

✓ **Research Projects, funded by the European Commission, H2020, Horizon Europe 2022**

PIACE	*Passive IsolAtion CondEnser*	2019 - 2022
EURAD	*European Joint Programme on Radioactive Waste Management*	
ORIENT NM	*OrganIsation of the EuropeaN Research CommuniTy on Nuclear Materials*	*2020-2022*
PATRICIA	*Partitioning and Transmuter Research Initiative in a Collaborative Innovation Action*	*2020-2024*
ECC SMART	*Joint European-Canadian-Chinese Development of Small Modular Super-Critical Water-cooled Reactor Technology*	
PASCAL	*Proof of augmented safety conditions in advanced liquid-metal-cooled systems*	
PREDIS	*PRE-DISposal management of radioactive waste*	
ANSELMUS	*Advanced Nuclear Safety Evaluation of Liquid Metal using Systems*	2022-2026
ECOSENS	*Economic and Societal Considerations for the Future of Nuclear Energy in Society*	
ENEN2 plus	*Building European Nuclear Competence through Continuous Advanced and Structural Education and Training Actions*	2022-2026
FREDMANS	*Fuel Recycle and Experimentally Demonstrated Manufacturing of Advanced Nuclear Solutions for Safety*	
HARMONISE	*Towards Harmonisation in Licensing of Future Nuclear Power Technologies in Europe*	2022-2025
HARPERS	*Towards Harmonisation in Licensing of Future Nuclear Power Technologies in Europe*	
INNUMAT	*INNovative strUctural MATerials for fission and fusion*	2022-2026
SASPAM-SA	*Safety Analyses of SMR with Passive Mitigation Strategy – Severe Accidents*	

Within the **PIACE** project, in 2022, activities were carried out within the work package: WP5 – Dissemination, education and training (RATEN coordinator).

Within WP5 RATEN ICN was responsible for the creation of two Deliverables: "Webinars collection" and Virtual workshop "Nuclear innovative technology enhancing safety of European citizens - Workshop lecture book".

Representatives of RATEN participated in the "Innovation in Nuclear Safety: Design, Experience and Lessons Learned" seminar that took place on November 8, 2022 in Rome.

During the 3rd General Meeting of the PIACE project, RATEN ICN held the presentation "WP5 Dissemination, Education and Training".

In carrying out the **EURAD** project, RATEN ICN participates in the Work Packages: CORI, FUTURE, ROUTES and UMAN, within which, in 2022, it carried out the following activities:

- ***FUTURE:*** "batch" sorption tests of Tc (by means of its chemically stable counterpart Re) were carried out on a clayey rock sample (red clay taken from the Saligny site), under oxidizing conditions and in an argon atmosphere (O2~ 0.1%), with and without the addition of a reducing agent.
- ***CORI:*** The influence of degradation and organic molecules on Ni-63 mobility by hardened cement pastes (HCP), based on EMC I, was studied. The organic molecules selected for this study are formic acid, identified as the main degradation product of spent ion exchange resins. The values of the distribution ratio Rd were obtained by means of the experimental method in "batch", at different pH values of the water in the pores of the cement, used as an indication of the degradation status of HCP suspensions.
- ***ROUTS:*** Contributions to the realization of deliverable D9.13 "Case studies on shared solution between Member states", for which information was transmitted regarding the provisions of the Romanian regulatory framework regarding the import and export of radioactive waste and spent nuclear fuel, as well as the experience of Cernavoda NPP in sending radioactive waste (incineratable and metallic) to Belgoprocess for incineration and Studsvik AB for incineration and melting.

Within the **ORIENT NM** project, in 2022, the Vision and Strategic Research Agenda in the field of nuclear materials were completed, two fundamental documents for the creation of a European partnership in this field, which define the strategic research directions that will be the basis for establishing the research program over the next five years.

In parallel with the efforts to finalize the vision document, the previous experience of the partners in the creation of the joint European programs (EJP) EURAD and CONCERT was analyzed and the mode and requirements for participation in the European co-financed partnership in the field of materials were adopted. RATEN ICN provided input on how to mandate the participants in this partnership, which reflects its own experience in the preparation process of the two EURAD programs, thus contributing to the realization of the deliverable: Deliverable 1.5 – Procedures for mandating national organizations and core group.

Also, RATEN ICN supported, together with other members of the Euratom Program Committee - Fission, the inclusion in the Euratom Program of funding the partnership for the study of nuclear materials. As a result of joint efforts, the European partnership was included in the 2023-2025 competition.

The objective of the **PATRICIA** project is focused on partitioning research for the efficient separation of Am from the burned fuel, experiments and code development to study the behavior of actinide fuel, and research supporting the licensing of the MYRRHA reactor. In 2022, work was carried out on a dedicated measuring bench in the hot cell of RATEN ICN. Thus, profilometry measurements were made on the selected elements from 1 to 7, selected by SCK Mol.

In the same period, the modeling activities for structural analysis with the computer code ANSYS and TRANSURANUS were also completed with some improvements for the input data. ANSYS thermal analyzes are compared with those obtained from TRANSURANUS and a good agreement was found. ANSYS structural analyzes were performed on elements from 1 to 7 in axisymmetric condition. Detailed profilometry of PCMI deformed segments was analyzed on three 120 degree cylinder generators. The profilometry evaluations by ANSYS agree with practical profilometry measurements. 3D modeling and thermomechanical analyzes will be done with TRANSURANUS and ANSYS codes.

The "1st Technical Report Driver fuel safety" was drafted and delivered for the period 01/09/2020 - 28/02/2022, including the activities carried out within the work package.

ECC SMART is a collaborative project between research organizations from Europe, China and Canada, which aims to contribute to the development of SCW-SMR (Supercritical Water Cooled Small Modular Reactors) water-cooled modular reactors at supercritical temperatures.

RATEN ICN is involved in 2 work packages: WP 2 (Identification and corrosion testing of candidate materials for the realization of internal components of the SM-SCWR) and WP 4 (Neutron characterization of the SM-SCWR conceptual project).

Within work package 2 (WP 2) RATEN ICN participated in 5 technical meetings and the general meeting of the project. During the general meeting, the results obtained by all project participants were presented, on all work packages and - At the beginning of 2022, RATEN ICN performed all the analyzes to characterize the condition of the surfaces of the samples that were oxidized for 1000h at a temperature of 3800C and the pressure of 25MPa. These consisted of: morphological analysis of the oxides, microstructural analyzes by optical microscopy and SEM, analysis of the composition of the oxide layers by EDS, determination of the microhardness of the samples, the roughness of the oxidized surfaces.

In May 2022, the oxidation test began for 1000h at a temperature of 5000C and a pressure of 25MPa. After the test, the following were carried out: gravimetric analysis, morphological analysis of the oxides using the optical microscope and SEM, microstructural analysis by optical microscopy, determination of the Vickers microhardness and the roughness of the oxidized surfaces. In September, the oxidation test was initiated for 2000 h at a temperature of 3800C and a pressure of 25MPa, which was completed at the beginning of December 2022. After the test, gravimetric analyzes and optical microscopy were carried out.

The results of the oxidation tests obtained so far have been entered into a joint MATDB database, developed by JRC Petten, and into the project database, initiated in ECC SMART's Share Point.

In 2022 RATEN ICN made an area configuration that includes UO2 type fuel assemblies with a uniform enrichment of 5% U235. The main changes applied were:

- change of structural materials;
- reducing the temperature of the moderator: from 600 °C to 550 °C;
- increasing the distance from fuel assemblies: from 9mm to 18mm horizontally and the use of different vertical distances;
- the use of two types of fuel: UO2 with enrichment of 7.5%/9% U235 and MOX with 9.5% Pu;
- reduction of neutron leaks by introducing a Be reflector;
- calculations were made at the assembly level to determine the power distributions inside the assembly, determining the power of the hottest pencil in relation to the average power (PPF);

- it was investigated how the PPF could be reduced using different enrichments inside the assemblies and the use of several types of poisons (Er2O3 and Gd2O3), as well as their behavior during combustion;

- two types of control systems were investigated: with bars or with B4C plates.

The objective of the **PASCAL** project is to demonstrate the capability of advanced nuclear systems cooled with molten lead in ensuring a high level of nuclear safety. In 2022, he participated in the "General Assembly Meeting of PASCAL project and PASCAL JOINT WP1- WP3 workshop", May 2-6, 2022, Gothenburg, Sweden, which aimed to analyze the results obtained within the 6 work packages (WP) of the H2020-PASCAL project and participation in the Workshop dedicated to the topics addressed within the work packages WP1 (Safety of the fuel pin system) and WP3 (Safety of the reactor containment system). At the same time, the project workshop organized by ENEA at the ENEA headquarters in Bologna, October 17-19, 2022, was attended.

The development of methods for the treatment and conditioning of radioactive waste for which no adequate or industrially mature solutions are currently available, including metallic waste, organic liquid waste and organic solid waste, will constitute the objective of the **PREDIS** project.

Within WP4, preliminary tests of aluminum corrosion in a solution saturated in Portlandite were carried out and an experimental assembly was made and tested that allows the direct measurement of the volume of hydrogen generated by the corrosion of aluminum in the solution. In WP5 contributed to the realization of the intermediate report "Screening study results & selection of reference formulations", completed in July 2022 (MS33), in which a summary of the experimental results obtained by the partners involved in the realization of Task 5.3 is presented (CIEMAT, KIPT , NNL, NUCLECO, POLIMI, RATEN, SCK-CEN, SOGIN) and the three geopolymer matrices for which additional optimization tests will be carried out are described: a geopolymer recipe based on metakaolin, a geopolymer recipe based on slag of blast furnace and a recipe based on mixtures of precursor materials such as: metakaolin, blast furnace slag and power plant ash.

The objective of the **ANSELMUS** project is to significantly contribute to the evaluation of the security of HLM systems, especially ALFRED and MYRRHA. Between October 19 and 21, 2022, the launch meeting of the ANSELMUS project "Advanced Nuclear Safety Evaluation of Liquid Metal Using Systems" took place, a meeting organized by SCK CEN Belgium and ENEA (hybrid format), in Bologna, Italy.

RATEN ICN provided 4 presentations within WP3, WP5 and WP6, as follows:

- Mirela Nitoi (2 presentations), as responsible for Task 6.1 "Dissemination and exploitation of results" and Task 6.4 "Interaction with stakeholders",
- Daniela Gugiu (1 presentation), as responsible for subtask 3.2.2 "Lead transport tests of noble gases in a new installation",
- Minodora Apostol (1 presentation), as responsible for the work package WP5 "Social impact of innovative nuclear technologies cooled with heavy metals".

The **ECOSENS** project aims to create a neutral space where specialists in nuclear energy, social sciences, humanities will exchange views and collaborate with civil society and other relevant stakeholders to assess the social perspective on: (1) development and use of nuclear technologies; (2) assessment of the sustainability of nuclear energy taking into account the whole life cycle of current nuclear technologies; (3) developing a radically new economic model, based on the Supply System (SoP), for assessing nuclear energy. In 2020, the deliverables developed with the contribution of RATEN ICN were:

- D4.1 – Strategy and plan for communication, dissemination and exploitation of results
- D5.1 - Minutes of the Kick-off Meeting

Also within the institute were realized the design elements of the project (logo, architecture, web page design, template for documents adopted within the project, ppt template).

The **ENEN2** plus project has the following objectives:

- Analysis of human resources needs in the nuclear sector;
- Informing young people about the nuclear field and attracting them to the field;
- Improving skills through continuous education and training programs;
- Development of vocational training programs and networks;
- Establishing a mobility scheme for young people in the nuclear field;
- Internationalization and stakeholder engagement

Within the project, the working team from RATEN ICN participated in 2022 in the following activities:

- Project launch meeting (June 23 – 24);

- Launch meetings of WP1, WP2, WP3 and WP4 work packages. During the WP4 launch meeting, RATEN presented the proposals for involvement in this work package, as follows:
    - Development of a European VET vocational education and training platform concept (objectives, structure, technical requirements, including the opinion of the potential end users of the platform);
    - Development of the content of the platform;
    - Development of criteria for labeling VET offers;
    - Method for labeling mechanism / procedure..

- Revision of the questionnaire to identify human resources needs for industry, research centres, waste management organisations and Technical Safety Organisations (TSOs). The questionnaire has been completed, being available both online and in pdf format. It must be completed by the project partners by February 19, 2023. In addition, RATEN ICN is responsible for sending the questionnaire to research, TSO and radioactive waste management organizations in Bulgaria and Croatia.

FREDMANS' main goal is to increase the maturity of advanced nuclear fuel manufacturing and recycling methods, the objective being to provide a structured research and development framework that connects research on fuel manufacturing and reprocessing, together with the approach of new waste fractions, on on the one hand and the industrial application of the results, on the other.

The initial training program was developed, described in Deliverable 5.1 – Initial training program. It includes the description of the 4 courses identified for the beginning. Three of these will address aspects regarding the manufacture and characterization of nuclear fuels and will be preceded by a course dedicated to the requirements imposed on nuclear fuels for fast reactors.

The **HARMONISE** project aims to develop a holistic approach to achieve harmonization and standardization of methodologies, codes/standards and safety assessments on innovative fission and fusion technologies.

The opening meeting of the project was organized (hybrid format) by LEI (project coordinator) at the headquarters of the Lithuanian Representation in Brussels, Belgium, on September 19-20, 2022.

Each work package organized (using the Microsoft Teams online platform) meetings to launch work packages and tasks. The meetings will continue periodically, every month.

RATEN ICN developed deliverable D1.1 Stakeholder network. This deliverable provides a comprehensive list of stakeholders relevant to the project and, at the same time, establishes the right strategy to interact with them, giving them the opportunity to express and communicate their positions and views on the anticipated technical opportunities and challenges to be encountered as a result of the process of harmonization of authorization regulations. The list will be updated following the evolution of the project.

The HARPERS project aims to establish and clarify the benefit and added value brought by harmonized regulations and standards in priority areas related to radioactive waste management and decommissioning.

Within WP2, RATEN ICN analyzed the results of the CHANCE and EURAD-HUMAN projects, in order to identify recommendations regarding the harmonization of various aspects in radioactive waste management, including regulatory aspects. The recommendations regarding the harmonization of various aspects in radioactive waste management were extracted from the following deliverables of the CHANCE project: D2.2 "Synthesis of commonly used methodology for conditioned radioactive waste characterization", D2.3 "R&D requests in the field of conditioned radioactive characterization" and D2.6 "Synthesis of CHANCE project". The extracted recommendations were analyzed according to the template developed within Task 2.2 "Survey development and analysis" to be included in the analysis meant to identify the priority areas to be addressed within the WP3 – WP5 work packages.

The development of innovative structural materials for nuclear applications and the development of the qualification process for these materials for fission reactors with fast neutrons, cooled by lead and molten salts, as well as for demonstrative fusion reactors, is the objective of the INNUMAT project.

Following what was discussed at the project launch meeting on October 18-19, 2022 (virtual participation), the general content of the project and the activities that will be carried out within each work package were learned. (Website and Visual Identity; Project Handbook).

Discussions were held regarding the realization of samples and coverings of the structural materials that will be tested within the project (AFA, HEA).

Samples are awaited for corrosion and mechanical tests to begin.

The objective of the SASPAM-SA project is to transfer knowledge from the field of severe accident analysis at PWR level to the SMR iPWR field, together with methodological development and simulation activities specific to SMR systems.

In 2022, activity planning activities, project launch and each work package were carried out, as well as accident phenomenology investigation activities in order to select relevant sequences for severe accident scenarios.

Also within the activities coordinated by the European Commission, the following should be mentioned:

✓ ***Activities as a Member within the following platforms, networks and associations of the European Union:***

SNETP / ESNII

The SNETP platform is the European association recognized by the European Commission as a platform for technology and innovation (ETIP) with over 100 members (research organizations, universities and industry). The ALFRED project is included in the strategic research and innovation agenda of SNETP as a representative activity for lead-cooled fast reactor technology (generation IV reactors). During the general meeting of the platform (May 3 - 4), the evolution and status of the project was presented, with the main achievement consisting in the signing of the contract for the construction of the ATHENA and ChemLab installations.

The 2022 edition of the SNETP Forum (June 2, 2022) organized as an event adjacent to the FISA and EURADWASTE conferences (Lyon, May 30 - June 3, 2022) sent a strong message regarding the important role of nuclear energy in achieving climate goals and reducing dependence on energy imports based on fossil fuels in Europe. The need to ensure the development of Generation IV reactors, especially Advanced Modular Reactors (AMRs), with the first demonstration facilities operating by 2035 at the latest, was supported. The proposal for the formation of a European Partnership for Small and Modular Reactors (SMRs) initiated within the forum includes as a general objective the selection of 3 to 5 future SMR reactor projects (for LWR and AMR) on which the established working groups will focus. This approach will also allow the identification of appropriate fuel management systems for generation IV projects.

Within SNETP, generation IV reactors are promoted within the ESNII (European Sustainable Nuclear Industrial Initiative) pillar. The ESNII meeting that took place on April 13 was dedicated to the presentation and debate of the revision of the ESNII vision document. The ALFRED project remains in a priority position as an industrial initiative within ESNII with the objective of building a demonstration reactor by 2035. The agenda of the technical meeting of ESNII on October 18 included informing the representative of DG Research regarding the preparation of project proposals financed through the Horizon framework program Europe for the period 2023-2025, preparation of the partnership for SMR, approval of the update of the vision document and the status of ESNII technologies. In the presentation given by the FALCON representative, the PRO-ALFRED and ATHENA projects in Romania were mentioned.

ENS/HSC

The main actions carried out by the Scientific Council of the European nuclear society were: the creation of 2 position papers and the evaluation of the candidates and the approval of the awards for the "Best PhD" competition dedicated to young specialists. These actions were discussed and finalized through the meetings organized on April 26 and October 24-25.

The position paper on the potential of nuclear technologies for space applications reviews the use of nuclear techniques to date and the extensive programs carried out by the US, Russia and China highlighting the limited possibilities of the European scientific community to contribute to space exploration programmes. our solar system. Nuclear fission systems (microreactors) will be needed to enable long-duration missions to the Moon or Mars to ensure efficient propulsion and exploration activities on the Moon, Mars or other bodies in space. No fundamental technological advances are needed to build power systems based on nuclear fission, these systems could be developed within a decade. The document highlights the net advantages of generation IV fast reactor technologies (long periods without fuel supply) that can provide the energy needed for long-distance space missions, the realization of surface operations (robot workstations or with human operators capable of operating in areas extended for long periods of time). Underlining the limited existing capabilities in Europe (with limited contributions to the US space program) the document advocates for the preservation and strengthening of the EU as a potential partner in space exploration and supports the initiative of the European Space Agency (ESA) to develop a strategy for the development of European nuclear capabilities for space exploration programs.

The position paper on the role of nuclear energy for hydrogen production highlights the potential of nuclear energy for hydrogen generation underlining the need for official recognition of the fact that hydrogen generated from nuclear systems has a low carbon footprint, comparable to hydrogen generated from renewable sources; nuclear power provides an efficient energy source for hydrogen generation. Nuclear reactors can ensure the production of hydrogen both through electrochemical and thermochemical processes. The prospects for the realization of small and modular reactors (SMR) and advanced IV generation reactors will ensure lower costs as well as advantages such as the possibility of working at high temperatures, the recycling of nuclear materials through closed fuel cycles or the location of reactors in the proximity of consumers.

ETSON

The European Network of Technical Safety Organisations (ETSON) consists of 16 nuclear technical safety support and assistance (TSO) organisations, mainly from the European Union, but also from Japan, Russia, the UK and Ukraine, which support their national regulatory body. Following the war in Ukraine, it was decided to exclude the Russian Federation from ETSON's activities.

RATEN ICN has actively contributed to all ETSON activities, as follows:

ETSON General Assembly

In 2022, 2 General Assemblies (AGs) were organized, one organized in virtual space, using the Microsoft Teams video meeting platform, on July 7, and the other, in hybrid format, organized on October 13, in Garching, Germany.

During the ETSON General Assembly was presented the status of the activities of expert groups (Technical Council for Reactor Safety; Research Group; Communication Group; Young Researcher Program). ETSON's strategy will focus primarily on skills training and development, given the challenges that implementing new technologies brings to TSO's mission.

During the national reporting on national nuclear activities, RATEN ICN representative presented the development perspectives of the nuclear field in Romania, including life extension activities for Unit 1 at CNE Cernavodă, plans for Units 3 and 4 at Cernavodă and the stage of the activities dedicated to the realization of the ALFRED project, as well as the activities dedicated to the implementation of NuScale.

Technical Council for Reactor Safety Assessment (TBRS)

In 2022, two meetings of the Technical Council for Reactor Safety were held, organized as virtual meetings (7 July and 29 November 2022). Most of the meetings were dedicated to the presentation and discussion of the status of the working groups' activities. At the last TBRS meeting, the idea of creating a new group, dedicated to "Data and artificial intelligence (AI)", was proposed and agreed, which aims to follow the use of AI technologies in the evaluation of the safety of nuclear installations.

ETSON Communication Group

The activity of the ECG communication expert group was somewhat frozen in 2022 due to the fact that the lead organization of the group (SEC NRS, Russia) was excluded from ETSON activities at the beginning of the year (ETSON decision, as a result of the war in Ukraine). GRS took over the responsibility of leading the group, but only in the middle of the year, there were many syncopes in the activity.

The ETSON video (the format of which also contributed to the RATEN ICN representative) which was presented for the first time at the IAEA General Conference was a real success.

ETSON bulletin

The ETSON bulletin included as format ETSON News developed by three TSOs, according to the new rotation schedule. RATEN ICN prepared articles for the September newsletter, together with VTT and NRA.

ETSON conference

The ETSON conference was organized between October 11-13, and had as its slogan: "Current challenges for nuclear safety from the perspective of TSO". RATEN ICN representative participated in all the events of the Conference.

ETSON Awards

The ETSON awards ceremony was organized by JSP members in a hybrid format, on October 11, 2022, and chaired by the ETSON vice-president, M. V Haesendonck (BelV).

The members of the competition jury were chosen from among the reviewers and chairmen of EUROSAFE. Mrs. M. Niţoi was chosen as a member of the competition Jury, together with 4 other people (representatives of JSI, BelV, PSI, ENEA). In 2022 there were 7 candidate works, of which 5 works were selected to be presented during the festivity, giving ETSON members the opportunity to vote for their favorite work. The first two votes were given before the event – M. Niţoi evaluated the 7 works, using points between 1 and 10. As a member of the jury, M. Niţoi evaluated the candidate works for prizes, participated in the awarding of the ETSON prizes, offered feedback on the work of one of the award candidates and voted for the awards.

SET-Plan

In 2022, RATEN ICN represented Romania in the IWG 10 - Nuclear working group, and together with the representative of the Ministry of Energy, represented Romania in the SET Plan SG and in the SET plan Bureau.

The main activities carried out within the SET Plan aimed at::

(1) coordination of national and European efforts regarding energy policies, decarbonization and climate actions,

(2) monitoring the activities of the working groups and the implementation stage of the National Energy and Climate Change Plans (NECP),

(3) revising the work plans of the implementation groups, IGWs, stimulating the increase of cooperation between IWGs,

(4) adapting the energy transition to emerging developments, including increasing resilience in the event of crises such as the pandemic,

(5) defining the set of actions to strengthen the SET Plan position and effectiveness in the implementation plans.

In 2022, the annual SET Plan conference was organized under the presidency of the Czech Republic, with a detailed discussion of the new energy context resulting from the energy and geopolitical crisis.

RATEN ICN participated in the realization of the position paper SET Plan, Action 10 (Nuclear) through which the following priorities were expressed: (1) harmonization of SMR licensing in EC countries, both WCR and Gen IV, (2) facilitating implementing large LWR units with advanced safety features, based on mature technology and by reasonably simplifying authorization processes, (3) maintaining and strengthening European know-how, competences and nuclear technology infrastructure, (4) supporting of the use of nuclear energy for the production of hydrogen, (5) the use of appropriate funds to accelerate the implementation of the latest generation nuclear technologies.

The Workforce, Skills & Education working group within nucleareurope (formerly FORATOM) aims to represent a good practice and an experience exchange tool for education and training providers and human resource managers in Europe. At the same time, it aims to develop an experience exchange program for young professionals in the nuclear sector, between companies in Europe, with the possibility of extending it to organizations outside Europe.

The RATEN ICN representative is part of 2 subgroups: "Increasing the attractiveness of the nuclear field" and "The need to create competences in the nuclear field".

In 2022, he attended 2 online meetings of this group as follows:

- February 24 . During this meeting, updates of the 4 subgroups of the group were presented (Increasing the attractiveness of the nuclear field; The need to create skills; Reconversion options; Experience exchange program). Regarding subgroup 2 "The need to create competences in the nuclear field", it was emphasized that the activities will start with the approval of the ENEN2plus project, nucleareurope coordinates the task "Identification of human resource needs for the nuclear industry - HR needs of the European nuclear industry" within this project. The participants from Belgium, Bulgaria, France, Romania, Switzerland and Great Britain as well as the organizations EHRO-N, ENEN and ENS presented the most important activities in the field of human resources, education and training. Romania, through RATEN ICN and Nuclearelectrica, expressed the fact that the new projects of the Romanian nuclear program will need highly qualified workforce.
- November 17. The report "For a dynamic of European skills in the nuclear field", presented by France in June 2022 within the Council of the European Union, was discussed. During the discussions between the participants and the nuclear adviser of the Permanent Mission of France to the European Union, possible actions that can be taken by the industry and the EU member states in order to maintain a high level of expertise in the nuclear field were discussed.

✓ ***Acctivities within the European Consortium FALCON (Fostering ALFRED Consortium), between Romania and Italy, intended to promote the ALFRED project***

The cooperation activity within the FALCON consortium took place in the same format established by the partnership agreement, consisting of monthly meetings of the expert group, thematic meetings organized on the specific themes of the 8 working groups: research, design, authorization, education and specialization, projects minor (supporting infrastructure), major project (reactor), expansion of the consortium through cooperation agreements and European affairs).

The sustained collaboration between FALCON members involved the development of activities related to the realization of the ATHENA and ChemLab experimental installations, the realization of the project proposal for the expansion of the research, testing and qualification infrastructure, the coordinated development of research programs, participation in the EURATOM research framework program, the organization of thematic seminars with CNCAN, education and specialization actions or participation in international conferences as well as coordinated actions at European and international level to promote LFR technology and ensure the continuation of the ALFRED project. The main results obtained during 2022 included:

Realization of the 4ALFRED/POCIDIF project proposal

The necessary activities for the development of the project proposal were carried out with the objective of completing the experimental infrastructure supporting the implementation of the research, development and qualification programs of the components in accordance with the structure established by the consortium and provided for in the national roadmap for research infrastructures. A constant dialogue was carried out regarding the technical aspects for Meltin'Pot and Hands-on necessary for the feasibility studies.

The realization of the project will complement the infrastructure that is being built (ATHENA and the ChemLab laboratory) with the facilities provided for in the ALFRED project, namely: HELENA 2, ELF, HandsOn and Meltin'Pot) and will finance the research activity associated with the development of the infrastructure.

The construction of the infrastructure is to be financed as a predefined project from European structural funds through the operational program for intelligent growth, digitization and financial instruments (POCIDIF). The proposal was finalized after the necessary iterations with the Ministry of Research, Innovation and Digitization, and submitted for approval to the European Commission.

Participation in projects financed by the EURATOM research budget

The partners of the FALCON consortium continued the fruitful collaboration within the competitions organized in the framework research programs EURATOM HORIZON 2020 (2013-2020) and HORIZON EUROPA (2021-2027).

Thus, during 2022, the PIACE project dedicated to the development of the concept for the passive waste heat removal system applicable to reactors cooled with liquid metals was completed, a project launched in 2019 in the Horizon2020 research framework program. The ORIENT-NM project (with the participation of RATEN ICN and ENEA), launched in 2020, continues its activities, with the final deadline being 2023. Also the PASCAL (2020-2024) and PATRICIA (2020-2024) projects, the works are in progress.

For the competition organized within the HORIZON Europe framework research program, RATEN ICN participated in 7 project proposals relevant to the ALFRED reactor, all of which were approved for funding and launched in 2022, with the participation of FALCON partners in 4 projects:

- SASPAM-SA, coordinated by ENEA, has as its general objective safety analyzes of SMR reactors with strategies for passive mitigation of severe accidents; the project has a completion date of 2026.
- HARMONISE, aims to harmonize and standardize nuclear safety methodologies, codes and standards, the project has a completion date of 2025.
- INNUMAT, has as its general objective the development of innovative structural materials for nuclear applications and the initiation of qualification activities for generation IV and SMR reactors, including for ALFRED; completion date 2026.
- ENEN2Plus, with the general objective of ensuring European competences in the nuclear field through advanced education and specialization actions, is of major interest for the training and provision of specialized human resources necessary for the ALFRED project. The project is scheduled for completion in 2026.

Participation in conferences, events and demonstrations organized at national and international level

The status of the ALFRED project and the results obtained in the last year in terms of the investment and the dedicated research program had a good representation in the NUCLEAR 2022 annual conference. In the session dedicated to advanced nuclear systems, 7 papers dedicated to the LFR technology and the ALFRED reactor were

presented by FALCON members. Taking into account the great interest that the ALFRED project has generated among industrial actors, the constant dialogue, the dissemination of opportunities, mutual information or cooperation agreements concluded with industry representatives (ROMATOM, SNN, Walter Tosto), the FALCON round table was organized during the conference -RHEUMATO (May 19, 2022). 25 specialists, representatives of the consortium, representatives of ROMATOM and 9 companies supplying equipment and services in the energy field participated.

At the international conference organized by the IAEA for fast reactors and associated fuel cycles (FR22), which took place in Vienna between April 18-23, LFR technology was widely represented and the ALFRED project promoted by the FALCON consortium was present with 7 papers .

FALCON members also participated in the promotion and support activities of the ALFRED project within the relevant European and international organizations (SNETP, ESNII, IAEA, NEA/GIF).

CNCAN seminars

In order to familiarize CNCAN specialists with the specific characteristics of LFR technology and ALFRED reactor, 9 seminars held by Falcon specialists were organized. The topics of the seminars included aspects of lead technology, fuel, reactivity control, design of component systems, thermohydraulics, release of fission products or coolant chemistry.

Cooperation with the International Atomic Energy Agency (IAEA) Vienna

Collaboration with IAEA Vienna was also supported this year by RATEN ICN's participation in the Research Program Coordinated by this international body (CRP-type research projects), the International Project for Innovative Reactors and Fuel Cycles INPRO (International Project on Innovative Nuclear Reactors and Fuel Cycles), involvement in the Technical Assistance Program and Regional Projects, active participation in the network of analytical laboratories for measuring environmental radioactivity, ALMERA and RANET.

The ongoing research contracts in 2022 in RATEN ICN were:

- RER2018 - Analyzing Low Carbon Pathways towards an Ambitious Decarbonized Energy Sector by 2050
- RER9160 - Strengthening Capabilities on Safety Assessment and Risk Informed Decision Making
- RER1022 - Enhancing Utilization and Safety of Research Reactors
- ROM9/038 - "Further support for the safe management of radioactive waste and spent nuclear fuel in Romania" (Support for the long-term improvement of radioactive waste and spent fuel management in Romania) (2020 - 2022).
- CRP T13017 - Management of Waste Containing Long-lived Alpha Emitters: Characterization, Processing and Storage
- Research agreement no. 22755 (CRP No I31032/2018-2021) – Neutronics Simulations of the CEFR Start-up Tests using Monte Carlo computer codes (SERPENT 2, MCNPX) – Numerical simulations of the start-up tests of the CEFR reactor with Monte Carlo codes
- IAEA CRP Nr 24320: Characterization of spent CANDU type fuel in view of long term storage and final disposal Duration (Characterization of spent CANDU fuel in view of long term storage and final disposal) (2020-2024)
- CRP No. 24966 - Benchmarking available computer codes in RATEN-ICN Pitesti for thermal-hydraulic analysis of liquid-metals cooled reactors
- INPRO ASENES SMR (ASENES pilot study for "Implementation scenarios of small modular reactors")
- Update of e-learning and distance learning tools to support INPRO trening

✓ Coordinated research projects, CRP (Coordinated Research Project)

Within the **Research Agreement no. 22755, CRP I31032 - Neutronics Benchmark of CEFR Start-up Tests**, RATEN ICN submitted to the IAEA the contributions to the drafting and revision of the IAEA TECDOC document dedicated to it.

The **CRP T13017 project - Management of Waste Containing Long-lived Alpha Emitters: Characterization, Processing and Storage**, aims to develop new technologies regarding the characterization and processing of waste

streams containing long-lived alpha emitters (including spent radioactive sources removed from service) of different activity levels and physical states.

At the September 2022 report, the work "Radiochemical Characterization Methods of Spent Resin Waste Containing Long-Lived Alpha Emitters from Purification Systems of Cernavoda NPP" was presented. Within this, methods were presented for determining the activity of 3H, 14C, 137Cs, 241Am and 242Pu from used resin IRN150 from used resin storage tanks, using destructive and non-destructive methods, as well as the results obtained after analyzing the samples by liquid spectrometry scintillation, gamma spectrometry and alpha spectrometry.

Also, methods were presented for determining the activity of 3H, 14C, 137Cs, 241Am and 242Pu in the water accompanying the spent resins IRN150 in the spent resins storage tanks (freestanding water), using destructive and non-destructive methods, as well as the results obtained from analyzing samples by liquid scintillation spectrometry, gamma spectrometry and alpha spectrometry.

From the results obtained from the characterization of the resin samples as well as from the results obtained from the characterization of the free water samples accompanying the resin, calculations were made regarding the recovery yield of the radionuclides of interest.

The device for taking resin samples from the storage tanks at CNE Cernavodă was presented.

Through the **CRP project No. 24320 - Characterization of spent CANDU type fuel in view of long term storage and final disposal (Characterization of spent CANDU type fuel in view of long term storage and final disposal)** is proposed:

- Development of a non-destructive method for measuring the thickness of the oxide layer based on the eddy current technique and its use for studying the distribution of the thickness of the oxide layer on the surface of spent nuclear fuel;

- Carrying out tensile tests on samples taken from used fuel element sheaths to determine the mechanical parameters of the material and correlating the results with the microstructure, oxide layer thickness and hydride concentration in the fuel element sheaths;

- Testing of methods for determining the content of beta emitters in samples taken from the fuel analyzed in point 1 and determining the content of organic and inorganic Carbon-14 in the sheath of the fuel element.

In 2022 RATEN ICN Pitesti participated in two work meetings:

- Virtual meeting to discuss the draft technical document "Spent Fuel Characterization" - March 3, 2022;
- Second Research Coordination Meeting on the Coordinated Research Project on Spent Fuel Characterization EVT2101323, September 20-23, 2022, Kalmar, Sweden.

The annual report containing the status of the works carried out within the project and a document with the detailed presentation of the works carried out in the second year were produced.

CRP No. 24966 - Benchmarking available computer codes in RATEN-ICN Pitesti for thermal-hydraulic analysis of liquid-metals cooled reactors aims at improving the understanding of accident sequences in fast reactors, validating the IT tools owned by the institute and, in particular, improving technical skills in the field of safety analysis for innovative systems. The contract was signed in 2022. The activities carried out during the first year of the contract consisted of:

-modeling of the NACIE-UP Loop with eutectic lead-bismuth with code RELAP5/MOD4.1 in accordance with the specifications provided by ENEA Italia;
- modeling the test section of the Loop with the ANTEO+ subchannel code;
- comparing the results obtained on the ADP-10 and ADP-06 tests with the provided experimental results;
- obtaining results for the "blind" calculation phase for the ADP-07 test;
- organization of data and results in the format required by the CRP..

✓ Regional projects

Through the **RER2018 - Analyzing Low Carbon Pathways towards an Ambitious Decarbonized Energy Sector by 2050** project, the aim is to assist member states to achieve the objective of the Paris Agreement and, at the same time, to help prepare national energy and climate plans and nationally determined contributions . RATEN ICN participates in this project, also ensuring the quality of NCP (National Counter Part). In 2022, training activities were carried out for the use of MAED and MESSAGE calculation tools. From RATEN ICN, one person participated in the MED course, in online format. Representatives from the Ministry of Energy, CNCAN, SNN and CITON participated in the training activities.

The **RER9160 project - Strengthening Capabilities on Safety Assessment and Risk Informed Decision Making** aims to strengthen the capacities of member states in the field of safety assessments and risk-informed decisions, to support the management of severe accidents. In 2022, two actions were carried out:

- Participation in the regional seminar "Integrated Risk Informed Decision Making", organized by the IAEA at the headquarters of the Czech nuclear regulatory body (State Office for Nuclear Safety -SUJB), Prague, Czech Republic, between September 12-16, 2022. The seminar provided a discussion platform for current approaches to Risk-Informed Decision Making (RIDM), with an emphasis on the use of Probabilistic Safety Analysis (PSA) results for decision-making. During the meeting, the ways in which PSA results can support different types of decisions regarding nuclear installations (from design, to authorization, operation) were discussed, taking into account the specific aspects of innovative reactors and SMR.

Mrs. M. Nitoi was a member of the discussion panel and also presented the paper "Risk-Informed Decision-Making experience in Romania", with the following main elements: PSA Program for CNE Cernavodă; The use of RIDM in Romania (the perspective of the regulator, the perspective of the plant); New opportunities for the use of the RIDM process, given the national initiatives on advanced reactors and SMRs.

- Participation in the international IAEA conference on Topical Issues in Nuclear Installation Safety (TIC2022), organized in Vienna, at the IAEA headquarters, between October 18-21, 2022

Mrs. M. Niţoi was chairman for the "Design Safety Features" session and also presented the paper "Towards innovative reactors licensing - ALFRED approach", in the "Safety approaches" session, and participated in the discussions of the "PSA & Risk-Informed Decision" session Making". The presentation referred to the national efforts to include the ALFRED project in the strategic documents, to the objectives of the pre-licensing stage of the ALFRED reactor, and to the specific activities that were planned by the FALCON members to achieve the proposed objectives.

The **RER1022 - Enhancing Utilization and Safety of Research Reactors project** aims to improve the utilization and support the safe operation of research reactors in the region. In 2022, the regional technical meeting of the RER2020021 / RER1022 project took place between November 21 and 25, in Tashkent, Uzbekistan. During this meeting, issues related to: infrastructure, modernization, safety culture, the research reactor aging management program and problems related to the modernizations carried out at the research reactors (modernization of: command control consoles, changing of the control rods) were discussed control, primary circuit pumps, heat exchangers, cooling towers and secondary circuit pumps), the infrastructure of research reactors (conversion of zones from HEU to LEU, modifications of active zones and changing the composition of the fuel elements used), the aging program (analyses performed for determining the degree of aging of the infrastructure – analyzes of concrete and active areas) and problems related to the use of reactors (production of radioactive sources, neutron activation analyses, tomographic analyses, color change of semi-precious stones).

On behalf of RATEN ICN, the paper titled "INR TRIGA Research Reactors Status and Utilization" was presented, which presents a summary of the institute's safety culture, the use of TRIGA reactors and the institute's ICERR program.

✓ Country project

ROM 9/038 - Support for the long-term improvement of radioactive waste and spent fuel management in Romania

The objective of the project is to strengthen the national capacity regarding the current management of radioactive waste and spent fuel, as well as the capacity regarding the introduction of fast reactors.

The IAEA approved the 5 nominations from RATEN ICN regarding the performance of professional training internships, as follows:

- Moise Andreea, FS-ROM9038-2105679 Training program in the field of Nuclear power reactors, domain: modeling and design of the active zone, ENEA-Bologna, Italy, September 25, 2022 – March 26, 2023;

- Vîlcu Andrei, Training program in the field of Nuclear power reactors FS-ROM9038-2105680, domain: chemical control systems in molten lead installations, ENEA-Brasimone, Italy, September 25, 2022 – March 26, 2023;

- Petrescu Daniel, Training program in the field of Nuclear power reactors FS-ROM9038-2105681, domain: interaction of structural materials with molten lead, ENEA-Brasimone, Italy, September 25 – December 22, 2022;

- Arva Mihai, Training program in the field of Nuclear power reactors FS-ROM9038-2105683, domain: design of experimental installations, ENEA-Brasimone, Italy, September 25 – December 23, 2022;

- Ivan Ana-Maria, Training program in the field of Nuclear power reactors FS-ROM9038-2105664, field: chemistry of cover gases and retention of radio-toxic elements, with emphasis on the release of volatile fission products from liquid metals (Pb / LBE), PSI, Switzerland, August 29, 2022 – March 1, 2023.

✓ The INPRO project (International Program for Innovative Reactors and Fuel Cycles)

1. INPRO ASENES SMR

ASENES pilot study for "Implementation scenarios of small modular reactors"

Application of the IAEA ASENES service in order to support capacity building and increase the competences of national experts for the evaluation of alternative nuclear technologies and collaboration, and in support of strategic planning for the sustainable development of nuclear energy.

The case study of Romania aims to investigate some scenarios for the development of the nuclear system under the specific conditions of the energy mix, based on the introduction of SMR, the level of penetration of renewables, considering strategic documents and climate policies.

In 2022, the following activities were carried out:

- analysis of predictions for energy demand over the last 3 decades with the MAED program, including a discussion on the evolution hypotheses of the main indicators; selection of interesting scenarios for energy demand - optimistic (+45%), moderate (+30%), pessimistic (+15%); discussion on the role of nuclear energy in the conditions of the future energy market, taking into account existing policies and strategies, as well as a set of determining factors (disruptive technologies, crises, demographic aspects, economic development, etc.); investigating the role of SMR systems based on the arguments that support their development and implementation, at the horizon of 2050.
- simulation with the MESSAGE program of the complementary development scenarios of nuclear and renewable capacities that differ by the level of penetration of renewables (high or medium) and the construction of new nuclear power plants (SMR systems or advanced high-capacity reactors) after the year 2050; proposing a mix of capacities with low carbon emissions (nuclear and variable renewables - wind farms and solar stations) as a solution to replace the coal plants that must be closed by 2050.
- two progress reports were made for the activities carried out (August 2022).

2. Update of e-learning and distance learning tools to support INPRO training

INPRO provides interested Member States with e-learning courses and distance education on important issues regarding nuclear energy sustainability, through the Webex conference system, contributing to increasing the capacity of Member States to develop innovative NES and facilitating the transition to nuclear energy sustainability based on collaboration between countries. The main objective of these courses aims to familiarize with INPRO activities by communicating directly with IAEA experts with significant experience in the field. The readings include: (1) overview of INPRO activities, (2) INPRO methodology for evaluating NES as a whole and for specific areas, (3) NES analysis using the INPRO/GAINS analytical framework, (4) results regarding SMR in INPRO activities, including transportable nuclear power plants.

The main contributions of RATEN ICN delegates:

- updating and supplementing training materials (presentations, practical exercises, sets of questions/answers for the final examination) for online training assisted by instructors within the IAEA Learning Management System (LMS) platform. The training materials addressed the following topics: Economic aspects of nuclear energy; Modeling of nuclear energy systems (NES); Comparative evaluation of NES options; Development of roadmaps for improving the sustainability of nuclear energy.
- updating and completing training materials on the IAEA Learning Management System platform.

✓ Other actions:

- RATEN ICN participation in the activities of the **ALMERA** and **RANET** networks (Response and Assistance Network):

In 2022, the Radioprotection, Environmental Protection and Civil Protection Laboratory within RATEN ICN participated in the following actions organized within the ALMERA network: the training workshop on Quality Assurance / Quality Control and Integrated Quality Management in Environmental Radioanalytical Laboratories , the radioanalytical performance verification test: IAEA-TERC-2022-01/02 Proficiency Test Exercise and the annual ALMERA network coordination meeting.

- Participation in the activities of the **TWG FR (Technical Working Group on Fast Reactors)**
- Romania's representative in the TWG-FR, Mrs. M. Niţoi presented the report entitled "Romanian Involvement in Fast Reactors Activities". The presentation was structured in three parts: in the first part, the activities carried out within

the R&D program no. 12 of RATEN "Advanced nuclear reactors and fuel cycles", highlighting the main R&D activities in the LFR field that will be addressed in the short and medium term; in the second part, the current stage of the implementation of the ALFRED experimental infrastructure was presented with emphasis on the role of the experimental installations in demonstrating the safety aspects of the LFR technology; the last part mentioned, in addition to the activity carried out within the FALCON consortium on working groups, the participation in ongoing research projects and those approved within the last EURATOM "Horizon for Europe" competition.

- Participation in courses, workshops, technical training.

✓ Designation of RATEN ICN – ICERR

On 17.01.2020, following the evaluation by the IAEA, the Pitesti Nuclear Research Institute was designated as "International Center based on Research Reactor - ICERR" for the fields of "Education and Training (Education and Training" and "Joint Research and Development (R&D) Projects"

The designation of the institute as ICERR, along with 6 other branded institutes from the USA, France, Korea, Russia and Belgium, represents an international recognition of the research capability in the field of Romanian nuclear energy represented by RATEN ICN.

Within TRIGA Reactor Department, for the field "Education and Training" is provided training aimed at:

- Nuclear Safety
- Physics of Reactors
- Radioprotection
- Irradiation techniques
- Use of neutron beams

For the "Joint Research and Development (R&D) Projects" field, training is provided regarding:

- Fuel testing for generation IV reactors
- Production of radioisotopes with applications in medicine and industry
- Irradiation of materials of nuclear interest
- Structural analyzes using nuclear techniques

Among the actions carried out this year, the following stand out:

- Updating the institute's website on the page dedicated to ICERR with the offer of services that can be performed within the TRIGA reactor department https://nuclear.ro/icerr-iaea/;
- Participation in the event organized by the IAEA "Consultancy Meeting on International Center based on Research Reactor (ICERR Scheme) Implementation", June 13 - 17, 2022, during which the presentation "Presentation of RATEN ICN activities as ICERR" was held.
- During the 66th edition of the IAEA General Conference organized at the Agency's headquarters in Vienna, Austria, RATEN ICN delegates participated in the meeting of ICERR members, where the presentation titled "RATEN ICN activities as ICERR" was held, in which the "Education&Training" service offer that can be provided by the institute was presented.

OTHER COLLABORATION

❖ Activity under existing bilateral agreements

Continuity of cooperation activities was ensured within the existing bilateral agreements with internationally recognized research centers, namely CANDU Energy (Canada), DoE (USA), CEA (France).

A new agreement between RATEN and the Belgian research center SCK CEN was signed on October 26, 2022, the terms underlining the interest of both institutes in LFR technology.

The actions within the **Trilateral Agreement with the Mansoura University (Egypt), the University of Pitesti (Romania) and RATEN ICN Pitesti (Romania)** targeted the following activities this year:

- coordination of activities master student Nawal M.M.S. Elbassiony (Mansoura University, Egypt) for the elaboration of the dissertation and the preparation of the public support (C.A. Mărgeanu);
- - revision and improvement of the scientific paper submitted to the Journal of Taibah University for Science, KSA, according to the comments and recommendations submitted by the referees (C.A. Mărgeanu);
- - review submitted to Journal of Taibah University for Science, KSA, M. Sallah, C.A. Mărgeanu, N. Elbassiony, M. Mitwalli, A. Elgarayhi - "Evaluation of Radiobiological Impact on Human Organs using Monte Carlo Estimated Gamma Dose Rates for CANDU Spent Fuel".

❖ NEA / OECD France

Romania joined the NEA OECD in 2017, thus becoming a full member of this international organization. A number of Romanian specialists, from different institutions, were appointed to represent Romania in the thematic working groups that address, by combining their own efforts, current issues in the field of nuclear energy. In 2022, RATENICN representatives took part in the works of the following groups:

- *Working Party on Nuclear Energy Economics (WPNE) – dedicated to the analysis of the economic aspects associated with nuclear energy*
- *Working Group Reliability and Risk (WGRISK) – dedicated to aspects of nuclear reactor safety analysis*
- *Working Group on Analysis and Management of Accidents (WGAMA) - dedicated to the analysis and management of accidents*
- *Working Party on Technical, Environmental and Safety Aspects of Decommissioning and Legacy Management (WPTES – dedicated to technical, environmental and safety aspects of decommissioning and legacy management*
- *Working Group on the Characterization, the Understanding and the Performance of Argillaceous Rocks as Repository Host Formations (CLAY CLUB) – dedicated to geological storage in clay formations*
- *Expert Group on Repositories in Rock Salt Formations (SALT CLUB) – dedicated to geological storage in salt*
- *Expert Group on Geological Repositories in Crystalline Rock Formations – Crystalline Club (CRC) – dedicated to geological repositories in crystalline rock formations*
- *Expert Group on Physics of Reactor Systems (EGPRS) – dedicated to experts on reactor physics*
- *Forum on Stakeholder Confidence (FSC) – dedicated to methods of developing common trust, informed consent and approval of radioactive waste (RW) management solutions.*).

RATEN ICN's presence at *WPNE Group* is based on the competence acquired by its representative through assessments based on characteristic economic parameters for nuclear energy systems previously carried out within IAEA INPRO international projects and the national project "Assessment of the Romanian Nuclear Energy System using INPRO Methodology", as well as through its involvement in IAEA INPRO international projects dedicated to nuclear energy development and economic evaluation of nuclear energy nuclear technologies.

The activities carried out within the group of experts in economic aspects of nuclear energy WPNE of NEA contribute to the promotion and support of RATEN ICN's involvement in international collaborations aimed at economic aspects related to the development of nuclear energy systems and the fuel cycle.

The members of the WGRISK Reliability and Risk Expert Group are currently working on improving PSA studies and using their results effectively, with reference mainly to dealing with the impact of external hazards, risk aggregation and the multi-unit context.

The WGAMA - Analysis and Management of Accidents group addresses the problems of analysis and management of accidents, with an emphasis on the main challenges regarding thermohydraulics, CFD, severe accidents. It is possible that in the future it will also address issues related to Generation IV.

The *WPTES group* addresses the technical, environmental and safety issues of nuclear decommissioning and their management.

The *Clay Club group* attaches particular importance to the abnormal water pressure in the clay, observed in several underground laboratories made in sedimentary rocks. Measuring it, understanding the causes and defining the constitutive laws that govern the abnormal increase in pressure are practically the current challenges of the scientific community interested in this rock. Also, the challenges related to the area affected by clay excavation, such as biogenic corrosion, the unpredictability of the spatial distribution of stresses following excavation and the cement-clay interaction that reduces the swelling capacity of bentonite, still require careful investigation by the group.

The activities carried out within the *EGPRS* of the NEA contribute to the promotion and support of RATEN ICN's involvement in international collaborations aimed at aspects of reactor physics, with interest in the modeling of radiation and biological protection, associated with nuclear energy systems and the nuclear fuel cycle.

The *FSC* was established by the Radioactive Waste Management Committee (RWMC) of the NEA in 2000 and serves as a platform for understanding dialogue with stakeholders and to discuss methods for developing mutual trust, informed consent and approval of solutions. radioactive waste (RW) management. In 2022, the leadership of this Forum was taken over by Romania, and Dr. Diaconu Daniela, RATEN ICN Scientific Director, was elected by free vote as president of this group. On November 17, 2022, the representative of the institute, as president, coordinated together with the representative of NAGRA (National Cooperative for the Disposal of Radioactive Waste), Switzerland, the FSC Bureau Meeting.

RATEN ICN delegates participated in the action organized by NEA within the cooperation between Romania and Bulgaria, *"Workshop on Radioactive Waste Management and Stakeholder Engagement",* held between July 25-27, 2022, in Brasov. The workshop aimed for the participants to obtain information on the important aspects in the management of radioactive waste, the effective involvement of stakeholders and public communication practices in the nuclear sector. Also, the workshop aimed to stimulate discussions between participants to identify potential fields of cooperation between Romania and Bulgaria, as well as with the other partner countries in RINA (Regional Initiative for Advancement in the Nuclear Field), by presenting case studies and examples concrete regional cooperation in the field of radioactive waste management.

MEASURES TO INCREASE THE PRESTIGE AND VISIBILITY OF RATEN ICN

MANIFESTATIONS AND SCIENTIFIC EVENTS ORGANIZED BY RATEN ICN

In the context of the COVID-19 pandemic, RATEN ICN has decided that the **NUCLEAR 2022 "Sustainable Development through Nuclear Research and Education" Conference** from May 18 - 20, 2022, will be organized in a hybrid format (online and physical environment).

The NUCLEAR International Annual Conference, launched in May 2008, addresses research and education in the nuclear field from the perspective of their contribution to ensuring a sustainable development of society. Organized by the Pitesti Nuclear Research Institute under the auspices of the Romanian Academy, in collaboration with the University of Pitesti, the Academy of Romanian Scientists and the Romanian Academy of Technical Sciences, the Conference promotes themes and research activities that illustrate the contribution of nuclear energy to the energy security of each countries and in reducing greenhouse gas emissions.

The main objective of the conference is to promote nuclear energy as part of the energy mix that ensures the sustainable development of society by highlighting its contribution on a national, European and global level to the achievement of the objectives assumed by conventions and treaties, of the strategic directions of development, of the achieved stage of research in the field in pursuit of these objectives.

At the same time, the conference aimed at:

• the presentation, dissemination and promotion of the research activity and the capabilities of Romanian institutions, as well as the most recent and original results obtained in the development of this top technology, contributing to increasing the visibility of the nuclear research potential in Romania.

• facilitating a better knowledge of the state reached on a European and international level in the developments intended for the field of nuclear energy, with special emphasis on the development of Generation IV reactors, nuclear safety, advanced materials, radioactive waste management, radiation protection.

• strengthening the interface between university education, represented by teachers and students, and research to stimulate the interest of young graduates in the nuclear field and to attract the young generation to this field, which is facing an acute lack of personnel to take over the existing knowledge and thus ensure continuity a high qualification in nuclear energy.

• strengthening the collaboration between research, industry, operators and national authorities, so that they jointly meet the major objectives assumed at the national, European and international level aimed at reducing carbon emissions, security of energy supply and competitiveness.

The event attracted over 150 participants from the country and abroad (Belgium, Italy, France, Austria, Sweden, Germany, Great Britain, Egypt and Iran). The papers presented addressed topical issues regarding: nuclear security, advanced nuclear systems and Generation 4 and SMR, nuclear materials and technologies, radioactive waste management, radiation protection and environmental protection.

Conference structure

During the three days, the NUCLEAR 2022 Conference included in its structure sessions dedicated to the following topics:

- *Advanced nuclear systems and SMRs*
- *Radioactive waste management*
- *Nuclear safety and severe accidents*
- *Nuclear Safety, Nuclear Reactors and Nuclear Fuels*

- Nuclear technologies and materials

- Radioprotection, environmental protection

- Education and training in the nuclear field, knowledge transfer, Nuclear Awards 2022, Student Session Awards "Nuclear 2022"

Through the contributions of Romanian specialists included in this broad thematic palette, during the Nuclear Conference 2022 the research activities and capabilities of institutions in Romania were presented, disseminated and promoted, as well as the most recent and original results obtained in the development of this top technology, contributing to increasing the visibility of the nuclear research potential in Romania.

Conceived as an active interface between research and university education, represented by teachers and students, Nuclear 2022 acted again this year to stimulate young people's interest in research in the nuclear field and attract them to this field, which is facing a lack of young staff which will take over the existing knowledge and thus ensure the continuity of a high qualification in the nuclear field. In this sense, this year's edition, continuing the previous experience, included a special session dedicated to education, during which the most valuable contributions of the students of the University of Pitesti who are doing their bachelor's and master's theses within the institute were awarded.

The participation in the conference of the representatives of the national authorities and the nuclear industry contributed to the confirmation of the political support of the research projects in the nuclear field and the strengthening of the collaboration in this field, in order to achieve the common objectives regarding the security of energy supply, nuclear safety, the reduction of carbon emissions and increasing competitiveness.

Other **events organized / hosted by RATEN ICN** were:

- ✓ *Discussions regarding the continuation of activities regarding the implementation of the CNCAN/DOE agreement on peaceful applications of nuclear energy, CNCAN, IGJR, DoE, Oak Ridge and SANDIA, May 10, 2022, 7 participants and June 7, 2022, 5 participants;*

- ✓ *Information visit in the field of environmental protection and environmental management systems, CBRN Defense Improvement Center "MUSCEL", June 7, 2022, 15 participants;*
- ✓ *Reconnaissance visit within the exercise to resolve a tactical situation STX, Military Unit 01643, Pitesti, June 29, 2022, 10 participants;*
- ✓ *General information visit, Argeş County-Organization-BASARAB I Association of military personnel in reserve and retirement, Pitest, August 31, 2022, 53 participants;*
- ✓ *Documentation visit in the field of nuclear research, HighFive Robotics, Pitesti, October 24, 2022, 16 participants;*

- ✓ *ECOSENS project launch meeting, Belgium/SKC.CEN, France/SYMLOG, Czech Republic/ISAS CR, Italy/POLIM and UNICAS, Slovakia/UBM, October 25 – 26, 2022,10 people;*

- ✓ *Technical visit for the provision of maintenance services, Identiv Global Services, Germany, 3 – 4 May 2022 and 24 – 25 November 2022, 1 person;*

- ✓ *UMAN Workshop Task 3.6 Near-Field Uncertainties (Workshop UMAN - Uncertainties associated with the near field of a geological deposit), IRSN / France, SURAO / Czech Republic, TUS / Bulgaria, NAGRA and PSI / Switzerland, LEI / Lithuania, ONDRAF/NIRAS / Belgium, 24 – 25 November 2022, 10 people;*

- ✓ *Training on radiological characterization techniques of radioactive waste, NUCLEARELECTRICA SERV. SRL, Cernavoda, December 5 – 16, 2022, 7 people;*
- ✓ *Study visit, Faculty of Medical Engineering, Polytechnic University of Bucharest, December 8, 2022, 23 people;*
- ✓ *Training of the staff of the Nuclear Materials and Corrosion Section, to perform EDS analyses, December 9 – 13, 2022, 1 person;*
- ✓ *Inspections*
  - *Inspection for the annual verification of the physical inventory of nuclear materials (PIV) subject to nuclear safeguards control carried out by inspectors of EURATOM, IAEA and CNCAN representatives at RATEN ICN Pitesti, WRME material balance area, June 22-23, 2022, 3 people;*
  - *Routine inspection in the WRME material balance area, in accordance with the provisions of art. 84 of the Nuclear Safeguards Agreement (INFCIRC/193), August 10, 2022, 2 people.*

Dissemination of research results and knowledge transfer

Regarding the dissemination of the CDIT activity from RATEN ICN, this was achieved through:

- Publication by RATEN ICN of the following works:
  - 8 scientific/technical papers rated or indexed by the International Institute of Statistics (ISI) and WoS;
  - 43 scientific/technical papers indexed in international databases;
  - 2 scientific/technical papers in magazines, other than those cited or indexed;
  - 95 scientific communications presented at conferences with international participation;
  - 12 specialized books or published book chapters.

- RATEN ICN Pitesti edited numbers 23 and 24 of the Journal of Nuclear Research and Development, ISSN 2247-191X; ISSN-L 2247-191X (www.jnrd-nuclear.ro).

In the field of knowledge transfer, the researchers and specialists from RATEN ICN, as coordinators or mentors, ensured at the national level the coordination of higher education graduates, to complete the works of bachelor's and dissertation these and of doctoral students for the completion of doctoral theses.

In 2022, students in their final years at UPIT, UPB, University of Bucharest and Mansoura University, Egypt benefited from guidance from RATEN ICN specialists for the completion of their bachelor's and dissertation works, as can be seen from the table below:

University / Organization	Field / Specialization	No. graduates / master's students / doctoral students /
Polytechnic University of Bucharest	Thermoenergetics	1 (bachelor's)
	Energy and Nuclear Technologies	4 (bachelor's)
	Sustainable Development Management	1 (masters)
University of Pitesti	Energy and Nuclear Technologies	19 (bachelor's)
	Nuclear Materials and Technologies	21 (master's students)
	Economic-industrial engineering	15 ((bachelor's)
	Engineering and Product Manufacturing Management	11 (masters)
	Electromechanical	2 (bachelor's)
	Mechanics and Technology	1 (masters)
	Electrical engineering	1 (bachelor's)
The University of Bucharest	Biology	1 (bachelor's)
Mansoura University, Egypt	Reactor physics	1 (master's student)

RATEN ICN representation at scientific meetings, national and international events

The RATEN ICN specialists participated in events and demonstrations organized at the national level as follows:

- The 16th Edition of the WEC Central$Eastern Europe Energy Forum – FOREN 2022: Energy Transition Needs Regional Cooperation, Costinesti, Romania, June 12 – 15, 2022;
- Romanian International Conference on Chemistry and Chemical Engineering – RICCCE 2022, Sinaia, 07 - 09 September 2022;
- International Conference Days of the Romanian Academy of Technical Sciences - ZASTR 2022, Petrosani and online, 06 - 07 October 2022;
- Romatom - Nuclear Valley Meeting, Romania-France Nuclear Days, Bucharest, November 22 – 23, 2022;
- International Scientific Conference, "Applications of Chemistry in Nanosciences and Biomaterials Engineering - NanoBioMat", Bucharest and online, November 24 - 26, 2022.

In 2022, 111 RATEN ICN specialists participated in 87 international actions, their missions highlighting the following priorities:

I. Participation in the events under the auspices of the EC within the ongoing and future Projects:

a. working sessions and annual meetings of the European Projects contracted with the EC within the EURATOM H2020 Program, for the presentation and reporting of the status of the works undertaken, the finalization of future responsibilities correlated with the objectives of the projects;

b. activities within the European Organizations, Networks and Technological Platforms.

II. Participation in actions organized by the IAEA regarding:

a. coordinated research projects, CRP;

b. technical cooperation projects;

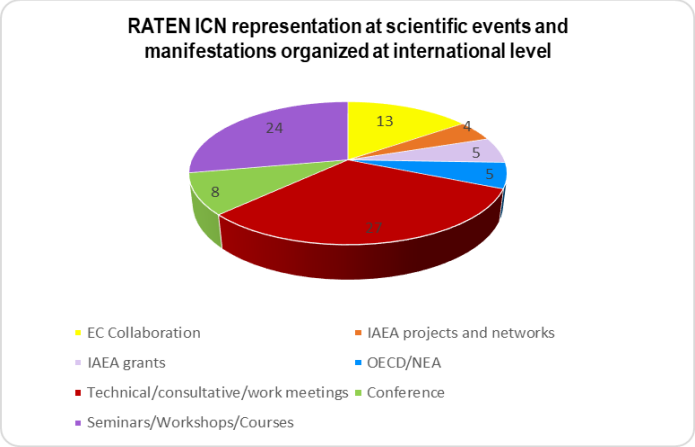
c. meetings of technical and working groups;

d. participation in seminars, workshops, technical meetings organized by the IAEA.

III. Participation in conferences and other actions through which the results obtained in the research-development and technological engineering activity of RATEN ICN were disseminated at the international level, delegates supporting specialized works;

Participation in these actions contributed to the professional improvement of the staff, to the harmonization of knowledge with those on the international level, the knowledge and acquisition of new practices and technologies in the field of activity.

The diagram below highlights the share of RATEN ICN delegations abroad



PERFORMANCE INDICATORS. DEGREE OF ACHIEVEMENT

Achieving performance indicators

• ***Technical-scientific indicators***

	Indicator	Percentage achieved
1	The number of CDIT/RDIT works completed and received within the RATEN ICN Annual Research - Development Program (300 works)	100%
2	The number of informative reports sent to CNE-Cernavoda for the provision of technical-scientific support and supporting research topics of interest in the operation of the plant (15 Cernavoda reports)	100%
3	Number of status reports submitted to the European Commission within the EURATOM Program (4 reports)	100%
4	The number of status reports submitted to the IAEA Vienna, within the CRP type projects (5 reports)	100%
5	Number of orders / contracts / services provided by RATEN ICN (108 contracts / orders)	100%

From the analysis of the technical-scientific indicators, the following can be concluded:

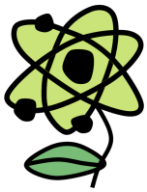
- The research and development works, proposed and approved by the Ministry of Economy, Energy and Business Environment, were handed over and received, according to the terms established in the RATEN 2022 Annual Research and Development Program;
- 100% commitments to CNE-Cernavodă and international organizations (IAEA Vienna and European Commission) were respected;
- RATEN ICN respected all its commitments for the year 2022 through the service contracts.

CONCLUSIONS

In 2022, RATEN ICN activities were focused on the operation of its own infrastructure in conditions of security and nuclear safety, in compliance with national norms, international agreements and treaties in the field, as well as on maintaining research capacity and competence in the field of nuclear energy.

Thus, the most important achievements can be highlighted:

- compliance with the commitments assumed within national, European and international projects;
- delivery and reception at the established deadlines of the research and development works, elaborated within the RATEN 2022 Annual Research Program, regarding the development of national technical support and international cooperation for nuclear energy;
- the use of own infrastructure and expertise in the field for the production of radioactive sources for industrial use, respectively for the decommissioning of those out of use;
- strengthening participation in European research and involvement in major projects (implementation of the ALFRED demonstrator in Romania);
- timely completion of services, contracts and orders, in compliance with contractual requirements;
- identification of new sources of financing by using the RATEN ICN infrastructure and competence in the field:
  - the production of radioactive sources for industrial use, the decommissioning of those out of use, the verification of some industrial gammagraphy installations;
  - provision of services in the field of radiation protection, treatment and conditioning of radioactive waste, metrology, engineering and design;
  - personal training courses for radioactive waste characterization activities.
- increasing the prestige and visibility of RATEN ICN, through representation at the actions organized at national and international level, at scientific demonstrations and events, as well as the inclusion of researchers in the editorial boards of journals recognized by WoS or included in international databases;
- active involvement in the field of management and knowledge transfer in the field of nuclear energy;
- the activation of RATEN ICN as an "International Center based on Research Reactors (ICERR)" for the fields of "Education and Training" and "Joint Research and Development (Joint Research and Development) R&D) Projects)".



TECHNOLOGIES FOR NUCLEAR ENERGY STATE OWNED COMPANY

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