



RÉPUBLIQUE
FRANÇAISE

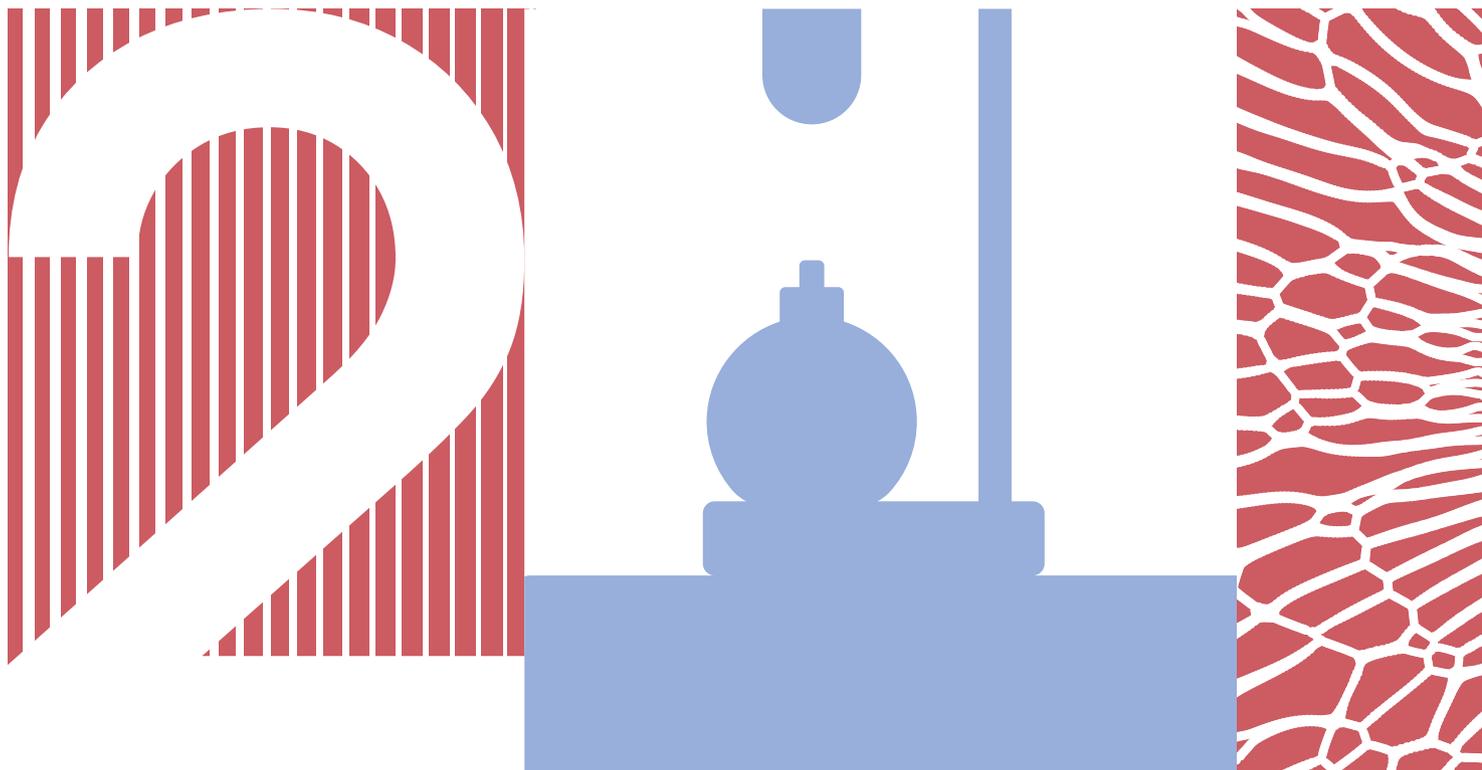
*Liberté
Égalité
Fraternité*

IRSN

INSTITUT DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE



ANNUAL REPORT 2022



MEMBER OF

ETSON

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A RESPONSIBLE AND CIVIC-MINDED INSTITUTE



RESEARCH



NUCLEAR SAFETY EXPERTISE



NUCLEAR DEFENSE SAFETY, NUCLEAR SECURITY, NUCLEAR AND CHEMICAL NON-PROLIFERATION



360° VISION



RADIATION PROTECTION FOR PEOPLE AND THE ENVIRONMENT



CRISIS AND POST-ACCIDENT



INTERNATIONAL



A HIGHLY-COMPETENT, INNOVATIVE INSTITUTE

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THE INSTITUTE FOR RADIATION PROTECTION AND NUCLEAR SAFETY (IRSN) IS THE PUBLIC EXPERT IN RESEARCH ON AND EXPERTISE OF NUCLEAR AND RADIATION RISKS.

As a french State-owned industrial and commercial establishment (EPIC), IRSN is under the joint supervision of the French ministers of the ecological transition, the Armed Forces, the energy transition, research, and health.

IRSN's missions serving public authorities and the population are to assess, research, protect, anticipate, and share. The institute's singularity lies in its ability to combine researchers and experts to anticipate future questions on the development and management of nuclear and radiation risks. IRSN employees are keen to publish their work and share their knowledge with society, thereby helping to improve access to information and dialog with stakeholders.

Independence, anticipation, excellence, and sharing are IRSN's essential values in order to contribute to public nuclear safety and security, health, environment, and crisis management policies.

For more information: www.irsn.fr





EDITORIAL

2002-2022, TWENTY YEARS OF HELPING TO IMPROVE RADIATION PROTECTION AND NUCLEAR SAFETY FOR IRSN

2022 marks the twentieth anniversary of the publication of IRSN's incorporation decrees and the definition of its missions. Over the past two decades, its teams have ensured IRSN's full involvement in radiation protection and nuclear safety and have contributed to its development.

RECOGNITION OF THE ROLE OF TECHNICAL EXPERT

Since its creation, IRSN has carried out expert assessments for a wide range of authorities, ministries, and institutions which periodically express their satisfaction with the institute's productions. Over the years, IRSN has made its expertise more professional through a continuous improvement process and listening to those for whom its assessments are intended. IRSN is therefore ISO 9001 certified. It also conducts joint audits with the ASN on regulatory processes integrating both an assessment and decision-making phase, in a logic of efficiency of the dual system. At European and international level, the institute has contributed to sharing and converging approaches, methods, and techniques implemented by technical safety organizations (TSO) to meet the expectations of consistency and effectiveness of their actions expressed by EU and non-EU public authorities. IRSN's involvement, alongside its European counterparts, in the creation of the Eurosafe Forum and ETSON, the European TSO network, reflects this concern. The latter contributed to the international recognition and foundation of technical experts in nuclear safety through the IAEA's actions, by contributing to the creation of the IAEA's TSO Forum and the TSO conference, which was held for the first time in France in 2008.



Marie-France Bellin,
Chairwoman of the Board



Jean-Christophe Niel,
Director General of IRSN

A PARTNERSHIP RESEARCH POLICY

In terms of research, the route taken is also important. Knowing that robust and impartial assessments are based on an ongoing independent research effort aimed at bringing scientific and technical knowledge to industry standards in due time, IRSN has equipped itself with simulation tools and experimental platforms allowing it to cover the main fields of investigation of its experts. It must continue to invest in this area in order to be ready, for example, to assess the dossiers submitted to it, both in the context of extending the operating time of the current reactors and the assessment of new reactor concepts, such as small modular reactors (SMR), or new treatment methods using ionizing radiation.

In accordance with Hcéres recommendations, IRSN has been working on developing structuring research partnerships, for example with the CNRS, Paris-Saclay University, and Gustave Roussy.

It has been involved in the development of European strategic agendas and has consistently responded to calls for nuclear safety and radiation protection research projects from the European Commission.

It is currently at the head of the PIANOFORTE partnership, which organizes all European radiation protection research and involves 58 bodies, including the most important in this field.

The numerous joint projects that IRSN manages or participates in, particularly those financed by the ANR, testify to the scientific quality of the institute's research. In its recent evaluation, Hcéres highlighted IRSN's ability to organize and develop this field of activity.

ANTICIPATION OF RADIATION AND NUCLEAR EMERGENCY SITUATIONS

With regard to crisis management, the institute has set up a dedicated technical center and means ready to be sent into the field enabling it to provide the authorities and the public authorities, at their request, with technical, health, and medical insight in all situations involving sources of ionizing radiation, whether they occur in France or abroad, if they are likely to have an impact on it.

As part of its crisis organization, IRSN was thus able to provide its expertise to the public authorities and the public during the Fukushima-Daiichi reactor accident or with regard to the situation of the Ukrainian nuclear power plants following the Russian attack in February 2022. It also regularly participates in national and international crisis exercises aimed at testing their effectiveness.

The methods and tools developed by IRSN are shared internationally, for example with the IAEA or under bilateral relationships.

More generally, the existence, within IRSN, of all the skills and components required to assess the risk linked to ionizing radiation favors synergies between them for the benefit of all its activities. This is particularly the case when preparing for or managing a crisis.

DIALOG WITH CIVIL SOCIETY AT THE HEART OF ACTION

Finally, in terms of dialog with society, the past two decades have seen IRSN's action move from being essentially based on information giving to a relationship where IRSN's expertise and civil society questions are shared. This can be seen, for example, in the continuity of technical dialog with society, in relation with ASN and ANCCLI, as part of the fourth periodic review of 900 MWe and 1,300 MWe reactors, or the creation of the ODISCE

(French acronym for "Opening up and encouraging dialog with civil society on expert assessment") committee, provided for in its 2019-2023 objectives and performance contract, the role of which is to advise the institute on how to establish new forms of dialog in the field of nuclear and radiation risk assessments.

Within the European Union and internationally, IRSN's action has been recognized, whether it is its contribution to the implementation of the Aarhus Convention in the nuclear field, or its involvement in dialog set up by ICRP between the inhabitants of the Fukushima prefecture living in an areas contaminated by radioactivity and radiation protection experts, which, month after month, have contributed to the development of a practical radiation protection culture in the population concerned. Another example of an initiative illustrating the evolution of dialog with society is the launch of participatory science projects, such as OpenRadiation, which aims to involve citizens in environmental radiation monitoring.

2023, TOWARDS GROWING CHALLENGES, IN PARTICULAR, IN NUCLEAR SAFETY

IRSN faces unprecedented challenges in all its areas of action.

Developments are the most significant and visible in the field of nuclear safety, in a context of climate and energy crises exacerbated by Russia's invasion of Ukraine: extension of the operation of EDF reactors beyond 40 years, or even 60 years, commissioning of the EPR, request for the creation of EPR2 reactors, CIGEO, the centralized storage pool, safety options file for the Nuward SMR, fourth generation SMR reactors, anticipation of the effects of climate change, etc.

In the field of nuclear safety, with the development of new technologies in the face of the deployment of new forms of malicious acts, such as malicious cyber acts or the use of drones.

In the field of health, with the development of new diagnosis or treatment techniques using ionizing radiation which must be fully mastered to be used on patients.

Regarding the environment, with the population's growing concern about this topic and the development of approaches, such as the exposome.

IN THIS CONTEXT, IRSN NEEDS TO ORGANIZE ITSELF

It must, at the same time, build on its fundamentals that recent debates on the development of the safety and radiation protection control system have confirmed, particularly in the context of OPECST's hearing on this subject:

- the necessary separation between assessment and decision;
- the essential link between expertise and research;
- transparency of its contributions.

It must adapt to the changing context, as it has always done, both in terms of human and financial resources and working methods, in conjunction with all its contacts.

It must maintain and develop skills to respond with relevance and timeliness to major future industrial events and demonstrate a high level of responsiveness.

All IRSN employees, whom we would like to thank for their professionalism and dedication, particularly in recent months, are prepared for this.

EDITORIAL

IRSN teams in charge of defense-related missions were mobilized throughout 2022 in order to carry out missions supporting the authorities - nuclear safety and radiation protection delegate for activities and facilities of interest to defense, senior defense and security officials - while maintaining a level of requirement in line with their expectations, and a high level of activity in the different areas within their competence.

As such, regarding safety assessments of defense ships and facilities, the review of cases relating to the commissioning of the Barracuda class *Duguay-Trouin* nuclear attack submarine, the second submarine after the *Suffren*, continued in 2022. At the same time, significant expertise work linked to operations involving the renewal of existing secret licensed nuclear facilities or the construction of new facilities was carried under French Ministry of the Armed Forces programs, not forgetting developments under the new-generation nuclear aircraft carrier program and the third generation nuclear launcher submarine (SNLE 3G).

In the field of civil nuclear facility safety, IRSN led, in support of the French Ministry of Energy Transition, in-depth expertise, carried out over a ten-month period, as part of the security reassessments of various CEA civil facilities. This work is set to continue in 2023 on the facilities of other operators.

In parallel to these expertise activities, in 2022, the institute continued to contribute to updating the regulatory framework governing the protection and control of nuclear materials, their facilities, and their transport (PCMNIT) with the drafting of orders for the implementation of the decree which entered into force

in January 2023. The latter modifies the safety review processes of the facilities and transport concerned in order to optimize implementation. Furthermore, inspections resumed at a rate comparable to that prior to the health crisis.

Internationally, IRSN provided support to the EURATOM Technical Committee under an advisory mission to the *Office for Nuclear Regulation*, the British regulator for the nuclear industry. This mission facilitated the implementation, following Brexit, of a new nuclear material control system in the United Kingdom.

Finally, in the field of chemical non-proliferation, in 2023, there is major work to be carried out on the Chemical Weapons Convention, in support of the Secretariat-General for National Defense and Security, the Ministry of Europe and Foreign Affairs, and the one in charge of Industry.

Reviewing these files resulted, for the institute's teams in charge of this, in a workload at least equivalent to pre-Covid levels.

In order to continue to guarantee high-quality support to the public authorities, regardless of changes in the safety expertise and research organization to be implemented, it seems essential to ensure that a level of skills and a volume of staff able to cover all the fields addressed by IRSN in the context of defense missions is maintained and, on the other hand, strict separation of expertise and decision-making functions. It is on this basis that the institute will continue to provide its sponsors with quality expertise, in compliance with the specifics of defense, safety, and nuclear and chemical non-proliferation activities.



Louis-Michel Guillaume,
Deputy Director General for Defense Missions and in charge of the Defense Security and Non-Proliferation Division





2022 HIGHLIGHTS

JANUARY

- Set up and first works of the ODISCÉ (French acronym for "Opening up and encouraging dialog with civil society on expertise") committee
- Start of VSEAL experimentation as part of the expertise of the CIGEO project for geological disposal of radioactive waste
- Publication of an operational assistance guide for radiotherapy professionals



FEBRUARY

- Start of the mobilization of IRSN's crisis organization due to the war in Ukraine
- Launch of the development of the EURATOM Accounting Integration software in the Base for the Preparation of Reports on Safeguards (ICEBERG) under the "France Relance" (France Revival) program

MARCH

- Public meeting reporting the results of the environmental radiation study of the Saint-Alban Saint-Maurice-l'Exil nuclear power plant
- Signature of a framework agreement for scientific collaboration with Paris-Saclay University
- End of the AMORAD research project on the dispersion of radionuclides in the environment and their impact on the marine environment and terrestrial ecosystems following an accident such as that of Fukushima-Daiichi (13 French partners in partnership with Tsukuba University, Japan)

APRIL

- Finalization of the European MEDIRAD research project (33 partners from 14 Member States): publication of recommendations to optimize the use of ionizing radiation in the medical field and improve radiation protection for patients and healthcare professionals

MAY

- Organization and hosting of *Rencontres Internationales* for high school students on radiation protection (80 students from various French regions, Japan, and Moldova)
- Publication of the notice on the impact of energy mix scenarios on the nuclear fuel cycle

JUNE

- Launch of the European PIANOFORTE partnership coordinated by IRSN (58 partners representing 22 EU countries as well as the UK and Norway)



- Delivery to CNRS'S CEO and IRSN's Director General of a common scientific roadmap

JULY

- Nuclear Fuel Thesis Day

AUGUST

- Step-up of IRSN's mobilization to serve public authorities and citizens in the context of the war in Ukraine



SEPTEMBER

- 66th IAEA General Conference: numerous bilateral exchanges and IRSN's organization of a *side event* for safety and radiation protection research facilities



OCTOBER

- *Fête de la Science* (Science Day): open day at some of IRSN's sites
- Submission of two expertise reports to the National Commission for Public Debate as part of the public debate on "New Nuclear Reactors and the Penly project"
- Launch of the PASTIS thermohydraulic research program studying the safety performance of passive systems
- End of the international PRISME 3 research project on fires and their spread vectors in a nuclear facility (12 partners from 8 countries)

NOVEMBER

- First "Integration Research Expertise" event on nuclear safety
- Launch of the European "Artificial Intelligence for Simulation of Severe Accidents" (ASSAS) research project coordinated by IRSN (13 partners)

DECEMBER

- Commissioning of the FUEL+ nuclear fuel behavior modeling software platform developed by IRSN



THE INSTITUTE FIGURES

ROADMAP
CSR
THE INDICATORS
ARE REVIEWED
ON THE FRENCH
VERSION OF THE
IRSN WEBSITE

€
BUDGET
39.3%
OF THE RESEARCH
BUDGET (EXCLUDING
FEURS, NORIA, AND
BÂTIMENT 625
PROJECTS)

€278
million
in revenue
€285 million
in expenditure, of which
€21,9 million
of equipment purchases

**TECHNICAL
SUPPORT**
FOR PUBLIC
AUTHORITIES AND
THE AUTHORITIES

52.3%
OF THE BUDGET FOR
TECHNICAL SUPPORT
AND PUBLIC INTEREST
MISSIONS (EXCLUDING
FEURS, NORIA, AND
BÂTIMENT 625 PROJECTS)

51
Technical opinions and reports
to the HFDS (senior official for defense
and security) of the French Ministry
of Energy Transition

65
Technical opinions and reports
to the Euratom Technical Committee
(CTE) and HFDS of the French Ministry
of Energy Transition

75
Technical opinions and reports
to the Nuclear Defense Safety Authority

489
Technical opinions and reports
to the Nuclear Safety Authority



HUMAN RESOURCES

44.61

years of age for women

46

years of age for men

78.9%

executives

21.1%

non-executive



PROFILE

1,744

PEOPLE (WORKFORCE AS AT 31/12)

1,590

Permanent contract

154

Fixed-term contract



34

employees loaned

24

secondments

57

PhD doctors or research directors

99

PhD students

17

post-doctoral students



INTERNATIONAL ACTIVITY OF THE INSTITUTE

324

bilateral cooperation agreements in force with research or expert bodies

44

countries concerned by these agreements

70

international projects under the aegis of the ENA/OECD, the European Commission, or the ANR

11

projects for which IRSN is the coordinator



RESEARCH ACTIVITY OF THE INSTITUTE

256

publications listed in the *Journal Citation Reports*

372

scientific contributions to congresses

25

theses defended

88%

of IRSN articles posted in open access with full text on HAL-IRSN (source: HAL as at 01/20/2023)



NUCLEAR DEFENSE SAFETY, NUCLEAR SAFETY, NON-PROLIFERATION

31

inspections on the premises of nuclear material holders

35

inspections during transport

124

national inspections on the protection and control of nuclear material conducted by IRSN

51

missions accompanying inspections relating to the international control of nuclear material

9

missions accompanying international inspections on the prohibition of chemical weapons

58

technical controls of means approved for the transport of nuclear material



CRISIS

WAR IN UKRAINE +7

real set-up of the crisis technical center

7

national nuclear crisis exercises excluding Defense-related activities

2

national nuclear crisis exercises concerning Defense facilities

20

meetings on the CODIRPA's post-accident work involving IRSN



PEOPLE AND THE ENVIRONMENT

800

whole body radiometry measurements taken for worker monitoring, 720 of which were taken using mobile resources

544

stations

139

measuring points for the ambient dose rate

597

sampling points for the monitoring of radioactivity throughout the country

5,742

environmental samples taken for radiation measurements



TRAINING

1,312

hours of teaching provided externally (university, engineering school, INSTN (French Nuclear Sciences and Techniques Institute), etc.)

767

hours of teaching provided during the 22 radiation protection training sessions

536

hours of teaching provided during 19 nuclear safety training sessions



A RESPONSIBLE AND CIVIC-MINDED INSTITUTE

As a public institution and stakeholder committed to nuclear safety and radiation protection, IRSN strives to provide solutions in these fields to meet current and future challenges which echo societal expectations. As such, it actively participates in the discussions and reflections of the various authorities and organisms it works with.

This is reflected in the gradual year-on-year roll-out of its Corporate Social Responsibility (CSR) policy: a social and environmental commitment whose objective is, in particular, to reduce and manage the impact of its activities on the environment.

In terms of openness to society, IRSN has engaged to work in partnership with civil society stakeholders. This enables the Institute to support the upskilling of these stakeholders as well as to listen to their concerns and expectations, and better take these into account in its research and assessment activities.

The Institute's actions also serve a public information role, helping the public better understand the issues related to nuclear and radiological risks. In this way, IRSN reaches out to the general public to raise awareness of these issues and explain the importance of its missions and how it is achieving them.

Finally, in terms of human resources management, the Institute aims, one, to improve the working conditions of its employees and, two, to bring onboard young people in training (internships, work-study programs, doctoral programs), to constitute a pool of future employees.

CORPORATE SOCIAL RESPONSIBILITY

In accordance with the commitments set out in its CSR 2021–2023 roadmap, the dynamics of the Institute's CSR policy are deployed through dedicated governance, which has now settled into its rhythm, and through a larger role in IRSN's overall governance, with the CSR Officer participating in the Board meetings, for example. At the same time, the information and discussion channels have been consolidated, driven largely by the dynamics of the CSR practices community and the publication of a newsfeed every two months, and by annual events, such as European Sustainable Development Week. The Institute also takes part in government initiatives targeting ecological transition, such as *Eco-responsible Public Services*.

EVENTS LINKED TO THESE COMMITMENTS

The Institute's CSR policy is driven in part by events organized throughout the year to raise awareness, inform, mobilize and exchange good practices in the four main areas of commitment laid out in IRSN's CSR roadmap:

- An Institute committed to the protection of all
- A mission and actions aimed at preserving the environment
- High standards of excellence and accountability
- Active involvement in society's development.

In the field of social responsibility, the week dedicated to the social aspect of CSR entitled "Vous avez dit responsabilité sociale ?" ("What about CSR?"), running from June 20 to 23, included round tables open to all on various topics: "Solidarity travel", "Solidarity actions", "Committed concierge service" and "Remote working and quality of life in the workplace". These events all helped to build in-house awareness of the actions taken by the Institute while at the same time throwing a spotlight on employee initiatives.

For the third edition of Sustainable Development Week, which took place from September 18 to October 6, mobility, biodiversity, digital sobriety, carbon impact, and climate were discussed during workshops or round tables organized on the Institute's sites and which could be attended remotely. A CHIP (CHallenge of IRSN for the Planet) challenge was launched in order to share slices of life, tips, and eco-responsible actions. Individual and collective missions were proposed and accompanied by publications giving advice on health, the environment, and sustainable mobility.

During October, IRSN welcomed the CDDEP (Club for Sustainable Development of Public Companies and Establishments), under the auspices of the CGDD (General Commission for Sustainable Development, an organism of the Ministry for Ecological Transition), which is tasked with contributing to the accelerated transformation of public bodies towards a sustainable development model. On this occasion, a "Climate Fresk" ("Fresque du Climat")^[1], a training session for Fresk facilitators, and a sneak preview of the Digital Fresk were organized, followed by a visit to the Institute's Emergency Response Center.

MEASURING THE CARBON FOOTPRINT

In 2022, IRSN published the calculations of greenhouse gas emissions related to its activities, based on 2019 data. This GHG emissions calculation enables IRSN to obtain a comprehensive overview of data relating to direct and indirect emissions. These figures will be updated and completed based on 2021 data to identify areas for action and keep the Institute on track along its low-carbon pathway.

IN BRIEF

SUSTAINABLE MOBILITY

Formalized by year-end 2021, IRSN's mobility plan was implemented in 2022 and concerns both business travel and commuting. It includes various measures aimed at reducing the use of private combustion engine vehicles, promoting shared or active modes of transport, and streamlining travel by promoting the use of videoconferencing. In addition, a sustainable mobility package has been put in place to promote alternative modes of transport to private combustion engine vehicles, by covering part of the commuting expenses of employees who use bicycles or carpool.

DIGITAL SOBRIETY APPROACH

One focus of the Institute's CSR policy is the structuring of the ecological transition and digital transition which has been laid out in a "Responsible Digital" roadmap. The main objective of this roadmap is to reduce the carbon footprint associated with digital activities, taking into account economic issues (impact of the increasing power consumption of digital technology), ecological issues (carbon impact), and social issues (access to digital technology and working conditions). Built around five pillars, it provides for training initiatives designed to build CSR reflexes in terms of purchasing and equipment life cycles, for example, and also covers the procedures for deploying the digital working environment for employees as well as data and infrastructure management.

CLIMATE FRESK

To raise awareness among the Institute's employees about the stakes of ecological transition, in particular meeting the challenges of climate change, IRSN has engaged in a Climate Fresks program^[1] ("fresques du climat") on its sites. This approach allows employees to better understand the links between human activities and climate change based on IPCC^[2] data. In 2022, these workshops attracted more than 200 participants, while a pool of facilitators was trained to run the Fresks for current and future sessions.

[1] Pedagogical tool developed by Cedric Ringenbach.

To learn more about it: fresqueduclimat.org

[2] Intergovernmental Panel on Climate Change, an intergovernmental body established under the aegis of the World Meteorological Organization and the United Nations Environment Programme.

OPENNESS TO SOCIETY

IN BRIEF

ENERGY SOBRIETY

In 2022, IRSN strengthened its energy sobriety measures by, for example, lowering temperature thresholds in office buildings, reducing air renewal rates and temperatures in testing facilities, and programming its reversible air conditioning and electrical heating systems. An information campaign was launched in order to promote best practices and employee participation was requested via suggestion boxes and exchanges within the CSR practices community.

ENERGY EFFICIENCY

As part of the France Relance plan for the energy renovation of public buildings, IRSN has begun construction of a new office building on the Cadarache site (Bouches-du-Rhône). By the end of 2024, it will house 14 entities, currently dispersed across the site. The aim of this project is to achieve HQE Sustainable Building "Excellent level" certification, for the entire life cycle of the building (construction and operation). It features a bioclimatic design that will reduce energy consumption by more than 50% and an internal layout co-designed with its users.

Furthermore, so-called "quick-win actions" were carried out on various IRSN buildings: centralization of the control of heating, ventilation, air conditioning and lighting equipment in building 05 Henri Jammet at Fontenay-aux-Roses, which mainly houses energy-intensive research laboratories; and thermal insulation of the facades of building C4 in Vésinet. These measures allow IRSN to commit on a low-carbon pathway in line with the objectives of the Government's energy sobriety plan.

Continuously developing its approach to openness to society for more than 20 years now, IRSN pursues a dual objective: one, sharing its technical knowledge to support stakeholders in their upskilling and enabling them to carry out their own expert assessments; and two, taking into account society's concerns and expectations in the Institute's research and assessment work to bring a more informed outlook to these topics. This is a second area that is continuously being developed.

IRSN 2022 BAROMETER: WHAT ARE THE TRENDS?

In July 2022, IRSN published the results of its annual Barometer on the perception of risks and safety by the French population. The web survey was carried out between November 15 and 22, 2021, before the conflict in Ukraine, polling around 2000 people. The aim of this Barometer, which has been produced for over 30 years, is to take an annual snapshot of the French people's stance on a broad spectrum of risks, as well as the confidence they place in those managing these risks.

Among the notable trends in this edition, French confidence in scientific institutions is on the rise (64%) and climate change is becoming their main concern, on a par with health (22% of responses). With regard to nuclear issues, 87% of French people demand a high level of nuclear safety and 91% consider that: "comprehensive information about the risks of facilities must be made accessible to all".

Among industrial and technological activities, according to the polling of the French population, nuclear power plants operation remains the activity that is most likely to cause a severe accident in France (27% of responses), followed by radioactive waste disposal (20%) and chemical facilities (18%). The opinion of the French on the construction of nuclear power plants is significantly more favorable than last year, whether concerning past constructions (60% favorable opinions, up 7 points) or future constructions (44% favorable opinions, up 15 points). The image of scientific experts is improving, up 4 points from November 2020, when it had been seriously eroded by the health crisis (54% favorable opinions). Among the nuclear stakeholders, the CNRS, ASN and IRSN are perceived as the most competent and credible, as in previous editions.

NEW "EPR2" TYPE NUCLEAR REACTORS: IRSN APPROACHED BY THE CNDP

As part of the public debate on "New nuclear reactors and the Penly project" organized by the National Commission for Public Debate (CNDP), Chantal Jouanno, its president, approached IRSN to provide the public with accessible information related to EDF's project to build six new EPR2 nuclear reactors. For the CNDP, such a debate should offer the public the opportunity to learn more about and to express themselves on the advisability of building these new nuclear reactors, and on the possible alternatives. A dozen or so public meetings, in Normandy and other regions, were organized at the end of 2022, to be continued into the new year.

The CNDP structured the public debate around 10 main questions concerning EDF's industrial program proposal. Examples include the timeliness of launching a new nuclear program; technical design; conditions and consequences of all kinds, including taking into account climatic and geostrategic uncertainties; and societal changes.

IRSN's expertise was called upon to write up two reports submitted to the CNDP on October 18, 2022 concerning: one, the lessons learned from the design,



20

IRSN INVOLVEMENTS
IN LOCAL INFORMATION
COMMISSIONS

111

REQUESTS MADE TO IRSN
BY LOCAL INFORMATION
COMMISSIONS



manufacture, construction and operation of EPR-type pressurized water reactors, and, two, on alternatives to EPR2-type reactors, with a focus on “small modular reactors” (SMR). These reports were presented by IRSN at two public debates, the first on November 22 focusing on the comparison of the EPR and the EPR2 and its alternatives, and the second on December 1st, concerning feedback from the Flamanville EPR.

In addition, the Institute participated in a pluralistic approach to the clarification of controversies, organized prior to the debate by its organizers, and in workshops such as “meet-ups” with citizens organized by the ATD Quart Monde association.

FOURTH PERIODIC SAFETY REVIEW OF 900 MWE REACTORS

IRSN has published a report in which it specifies to what extent and how it has taken into account the many exchanges engaged in during technical dialogue with civil society since 2014 as part of the fourth periodic safety review of 900 MWe reactors. A task force, a seminar, dialogue meetings and open public consultation have enabled IRSN to share knowledge and skills with citizens and to hear their expectations and concerns on the topics discussed. These various occasions have allowed the Institute to exchange ideas while conducting its technical assessments, prior to decision-making; but, above all these external points of view have helped inform IRSN’s perspective on the review dossier.

The report covers the questions brought up for each topic, such as compliance (a priority for the public in the online consultation in 2018) or improvements to emergency response plans in case of a core meltdown. It also specifies the IRSN notices and the corresponding educational documentation, as well as the reasons why some of the topics could not be covered. It was presented at the HCTISN on December 12, 2022. To expand on this review, the Institute explicitly integrated and mentioned in ten of its notices, published since 2019, answers to questions collated during technical exchanges and dialogues with civil society.

A FORUM FOR DIALOGUE

The creation of the ODISCE committee (French acronym for “Opening up and encouraging dialogue with civil society on expertise”) constitutes a new stage in the process of opening up to society. The aim of this committee is to boost the interactions between science and society around the expert assessment of nuclear and radiological risks. Comprising around twenty members with various profiles (participation experts, experts from associations, non-institutional experts, operator advisers and representatives of institutes that are signatories to the charter of openness to society, etc.), this body was set up in January 2022. Its mission is to advise the Institute on which dialogues to initiate in order to increase the relevance of the Institute’s risk evaluations, reflecting the concerns of civil society more precisely in the questions underlying these assessments. The creation of this committee fulfills a commitment made in the IRSN objectives and performance contract signed in 2019 with the Government. With ODISCE, the Institute makes a clear statement, announcing the structuring and lasting character of its Openness to Society initiatives. Through its work, ODISCE will help establish regular and in-depth dialogue on technical subjects relating to nuclear and radiological risks as well as the associated methods and assessments. The first topic for consideration by the committee concerned society’s involvement in the monitoring of the radiological state of the environment carried out by the Institute: the committee’s first technical notice, submitted to IRSN on November 28, 2022, includes 28 recommendations on methodology, with public interest in mind, and on specific actions and follow-up.

IN BRIEF

PARTNERSHIP WITH ANCCLI

Jean-Christophe Niel, the Director General of IRSN, attended the general assembly of ANCCLI (National association of local information committees and commissions) on June 28, 2022. He took the opportunity to review the many joint actions implemented in the fields of nuclear safety, radioactive waste, health, the environment, and crisis management. He also talked about the outlook for future assessments covering major safety and radiation protection issues, such as the fourth safety review of the 1,300 MWe reactors and the application for authorization to create CIGEO (a geological disposal solution).

NUCLEAR WASTE

The technical exchanges organized by ANCCLI, the CLIS (Local information and monitoring committee) of Bure, and IRSN on high-level waste (HLW) and intermediate-level long-lived waste (ILW-LL) continued in 2022. They focused on the global management of HLW & ILW-LL waste using a “serious game” type dialogue tool, and on alternatives to deep geological repositories.



Jean-Christophe Niel,
Director General of IRSN

After 10 years of implementing the IRSN’s Openness to Society Charter, we asked ourselves how we could further strengthen the interactions between IRSN and society, by envisioning new methods and expanding the scope of stakeholders involved. That is the objective of this new body. I want this ODISCE committee to come up with recommendations to help us question in a new light the way we do things or else bring new data to the table. For IRSN, it’s about being an even more civic-minded scientific institute contributing to health and environmental democracy.



Michel Badré,
Chair of the ODISCE Committee

There can be no useful science or technology, nor any sound democratic decision in complex technical areas, if experts and society do not discuss it in depth. Dialogue is the best and sometimes only way to build trust between experts and citizens, or even to simply ensure that trust is there at all. The practice of promoting interaction between experts and society is developing, and that should allow everyone to fully exercise their rights and responsibilities.

COMMUNICATION

One of IRSN's missions is to contribute to informing the public on nuclear safety and radiation protection. For the Institute, this means striving to raise awareness among the public, particularly young people, of the main issues related to radiological and nuclear risks, and the role of IRSN in terms of research, expertise, and monitoring. It also ensures that appropriate and objective information is made available to each target audience.

20 YEARS OF SCIENCE

Participation in the *Fête de la Science* (Science Festival), from October 7 to 17, 2022, was an opportunity for IRSN to showcase the research it has conducted since its creation, through an operation entitled "20 years of science". During this Festival, the Institute's experts and researchers were involved in various events nationwide. The aim was to explain to the public the radiological and nuclear risks, and the work carried out to better understand and assess these risks. Laboratory visits, exhibitions, fun workshops, interaction with the public: the Fontenay-aux-Roses (Hauts-de-Seine) and Vésinet (Yvelines) sites opened their doors to the public to present the Institute's missions in terms of monitoring, radiation protection, crisis management, and research. More specifically, the work presented during this event focused on how a criticality accident unfolds, IRSN's role in combating cancer, and crisis management, as well as the analysis and metrology of radioactivity in the environment. Lastly, the new version of the educational exhibition: "RADIOACTIVITY – Discover & Understand" was presented for the first time (see text below).

The Institute's researchers also participated in the Villages des Sciences (Science Villages) events held in Aix-en-Provence (Bouches-du-Rhône), Cherbourg-en-Cotentin (Manche), Nantes (Loire-Atlantique), Vinon-sur-Verdon (Var), and Gap (Hautes-Alpes), where they led various workshops to playfully address issues related to radioactive iodine, fire behavior, pressurized water reactor power plant fuel, the transfer of radioactivity to air or water, etc.

A total of around 170 employees attended nine events and welcomed more than 1200 visitors in the Île-de-France region, as well as 250 students in educational workshops.

At the same time, the Institute participated in *Science en direct* ("*Science Live*"), a show recorded in public in the Grand Gallery of Evolution (National Museum of Natural History, Paris) and broadcast live on the YouTube channel *L'Esprit Sorcier*, which offers ample opportunity for interactivity with the public. Presented by scientific journalist Fred Courant and accessible to all, this show highlighted in particular several topics studied at IRSN, such as natural hazards and the protection of nuclear facilities against the risk of flooding, and research conducted on the transgenerational effects of radioactivity.

Lastly, and still as part of the *Fête de la Science*, the Institute participated in the *Science in the Classrooms* initiative, where researchers met up with schoolchildren and high school students from southeastern France and guested in classrooms to present their professions as scientists and researchers and talk about the projects they were working on.

THE INTERNATIONAL HIGH SCHOOL MEETINGS ON RADIATION PROTECTION ARE BACK

After a two-year hiatus due to the health crisis, the International High School Meetings on Radiation Protection took place in Fontenay-aux-Roses on May 23 - 24, 2022. These events, which have been held for nearly 15 years by IRSN, in partnership with the CEPN (Study Center for assessment and protection in the nuclear field), the ASN (French Nuclear Safety Authority), the INSTN (French Nuclear Sciences and Techniques Institute), the Pavillon des Sciences of Bourgogne-Franche-Comté and the SFRP (French Radiation Protection Society), allow high school students from French and foreign institutions to meet each other and share their scientific projects on the risks linked to radioactivity carried out during the school year with the support of their teachers, accompanied by experts and researchers.

The projects for 2022 presented by some 80 students from different French regions, Japan and Moldova are multidisciplinary and voluntary. They provide an opportunity to raise awareness among young people of the risks associated with radioactivity and of various aspects of the practical side of radiation protection. Japanese high school students presented their projects remotely on lessons learned from the Fukushima accident; the Moldova students, who made the journey to Fontenay-aux-Roses, talked about the presence of radon in the wells of Moldovan villages. As for the French high school students, they had worked on various themes such as radioecology, radiation protection in medical and veterinary environments, and high-activity radioactive waste management around the world. In the course of these Meetings, the high school students also visited IRSN's research facilities in Fontenay-aux-Roses and chatted with experts and researchers in nuclear safety and radiation protection.

EXHIBITION ON RADIOACTIVITY GETS A MAKE-OVER

In 2022, IRSN completely overhauled the content of the exhibition: "RADIOACTIVITY – Discover & Understand" developed jointly with the ASN. This exhibition provides objective and educational information on radioactivity, its uses, the risks it may present, and its effects on health and the environment.

Composed of more than 80 panels divided into 11 themes, the "RADIOACTIVITY – Discover & Understand" exhibition, offering clear explanations and illustrated by computer graphics, is designed for anyone curious about the issues surrounding radioactivity. It has been made available for many years to schools, healthcare facilities, local authorities, and local information commissions.

This new version of the exhibition was presented for the first time at IRSN sites in the Île-de-France region, which opened their doors for the *Fête de la Science* (Science Festival).

IN BRIEF

EDUCATIONAL VIDEOS

In response to the 48% of French people concerned about the management of nuclear waste, which is perceived as an important source of risks (2021 edition of the IRSN Barometer), IRSN has produced a series of videos featuring researchers and experts. These educational tools address the questions that many people have about nuclear waste.

HUMAN CAPITAL

Ensuring the quality of working conditions in line with employee expectations and maintaining an attractive market position, anticipating skills renewal needs, welcoming young talent, and advancing in the field of equality in the workplace are all priorities implemented in the IRSN human resources management policy.

WELCOMING YOUNG PEOPLE

As part of its "young people" policy designed to meet the commitments made in terms of skills renewal and transfer, IRSN welcomes students on work-study placements every year. From technician to engineer, from manager to project lead, the work-study program covers a wide range of profiles for periods of one to three years. In the form of an apprenticeship or professionalization contract, this scheme enables young people to receive training while they work, as well as helping job seekers or people with disabilities get back into the workforce. In 2022, 27 new work-study students joined the Institute's teams, bringing the total to 47: 20 women, 27 men.

In parallel, 117 trainees (68 men and 49 women) were also onboarded: 27 were working towards an undergraduate diploma and 90 were working towards a Master's or postgraduate degree.

More generally, IRSN is rolling out a three-pronged action plan to boost recruitment of young people:

- Directing the recruitment of work-study students to anticipate and compensate for staff taking retirement; strengthening IRSN's skills in the emerging trades and professions; and creating a pool of candidates for permanent recruitment;
- Developing partnerships and strengthening relations with schools and universities, in particular with postgraduate institutions and schools offering work-study courses;
- Setting up targeted sourcing actions with specialized recruitment firms in order to make IRSN more visible on the labor market and attract new talent. In 2022, an employer brand was rolled out to optimize the recruitment of young people on the labor market.

FACILITATING MOBILITY TO ASN

On September 13, 2022, IRSN signed an agreement with the ASN on the mobility of the Institute's employees, enabling employees to follow a career path or implement a personal career project through mobility to the ASN. This agreement updates the previous agreement dating from 2011 and reaffirms the need for continuity of action between assessment and control. It also takes into account the institutional and organizational developments of the ASN and IRSN, as well as the increased need for nuclear safety and radiation protection skills.

The system provides for two possible forms of mobility: personalized support for employees, and the leveraging of experience acquired at the ASN when rejoining IRSN.

THE IRSN GENDER EQUALITY INDEX IS CHANGING

In February 2022, IRSN published its memorandum on equality in the workplace, based on five indicators which have measured various data since 2019: gender pay gaps, differences in the rates of individual pay rises between women and men, differences in the rate of promotions between women and men, percentage of employees who benefited from a pay rise on returning from maternity leave, number of employees of under-represented gender among the company's top ten wage-earners. For 2021, the overall score was 93/100: this is an improvement over the 88/100 score of the three previous years. This progress marks an acceleration in the Institute's policy on equality in the workplace and diversity as part of its corporate social responsibility policy. In particular, it results from the agreement on gender equality in the workplace concluded on June 9, 2021, which sets objectives for progress in the fields of job promotion, work-life balance, working conditions, and the reduction of pay gaps between women and men.



36.5%
OF WOMEN MANAGERS
IN 2021 (COMPARED TO
33.3% IN 2020),
A 3.2-POINT INCREASE

FEMALE/MALE EQUALITY
INDEX SCORE
93/100
IN 2021 (COMPARED TO
88/100 IN 2020, 2019
AND 2018),
A 5-POINT INCREASE

IN BRIEF

WORKING CONDITIONS

In 2022, IRSN pursued its policy of improving working conditions, mainly with an ambitious "Quality of life and working conditions" agreement to improve quality of life in the workplace, including, in particular, concessions with regard to work-life balance. This agreement is a follow-on to the conventional corpus which was extensively revised in 2021 to meet the challenges of employer attractiveness, particularly in terms of quality of life and working conditions: job & skills planning, training, workplace equality, disability policy, working from home, etc.



RESEARCH

Research is an essential activity for IRSN, which devotes around 40% of its resources to it. This level of investment, maintained in 2022, has two main objectives. First, it provides the Institute's teams in charge of assessing dossiers related to nuclear safety, to radiological protection of the environment, the public, patients and workers, to environmental radiation monitoring, or to human health, with new-found knowledge resulting from finalized research. This enables the teams to fulfill, in complete independence, their mission as public experts in radiological and nuclear risks, providing support to the public authorities in all these fields. Two, it involves looking further ahead, in an anticipatory or exploratory research approach, which is aimed at acquiring knowledge and skills in new paths or concepts, not only in terms of technology, but also in terms of organization.

Whatever their nature and scope – national, European or international – IRSN's research programs are designed, for the most part, as partnerships in conjunction with universities, laboratories, technical nuclear safety organizations, etc. They are also integrated in schemes such as the Nuclear Safety and Radiation Protection Research Program (RSNR) financed by the Investment Program for the Future and operated by the French National Research Agency or the European Commission's *Horizon Europe* Research and Innovation Framework Program. Finally, in order to define its research policy and govern its programs, the Institute draws on two complementary bodies: the Scientific Council and the Research Steering Committee.

SHARING AND DISSEMINATION OF SCIENTIFIC KNOWLEDGE

THE RETURN OF IN-PERSON SEMINARS

An essential element of efficient research, knowledge-sharing between scientists is the subject of regular meetings which were able to resume in 2022 in person after a two-year interruption.

The Institute's doctoral students met, as part of the 2022 Thesis Days, from March 28 to 31, to present the progress of their projects. This event was attended by 95 doctoral students, their supervisors, as well as representatives of partner organizations. In addition to providing a forum for exchange across the diversity of topics studied at the Institute, this event is an integral part of the doctoral students' curriculum, allowing them to work on presenting their activities, in the form of posters for first-year doctoral students and orally for the others.

Taking the same approach, Thematic Thesis Days on nuclear fuel are organized as part of a four-party partnership between IRSN, EDF, Framatome and the CEA. Here again, this event allows doctoral students or post-doctoral students to present their work. The tenth edition of these Thesis Days took place in July 2022 in Pertuis. It allowed nine IRSN doctoral students to share the progress of their work, both experimental and theoretical, with more than 30 specialists in the field. This work includes innovative ways to heat fuel with lasers.

2022 also marked the return of Safety Research Day, on June 9 in Cadarache. In addition to the research teams, this event was attended by IRSN employees in the fields of expertise and strategy management. Dedicated to scientific excellence and innovation, Safety Research Day, through plenary presentations and discussions around some thirty posters, illustrated the main research activities, namely modeling, experimentation, and the development of scientific simulation software. It also contributed significantly to rebuilding collective participation, which had been undermined by the health crisis, and enabled scientists and technical experts to meet up and share on a wide diversity of research topics all with same objective in mind: improving nuclear safety.

In the more specific field of data science, the second SCIDONI (Data Science at IRSN) seminar on May 12 and 13 was attended by nearly one hundred IRSN employees, members of the community of practices dedicated to the management and optimized use of data. Event highlights included: an instructional session, technical sessions, and round tables on the integration of data science and the development of artificial intelligence. This seminar helped boost IRSN's acculturation to data sciences and promoted cross-functional practices in this field.

Finally, as part of the technical assessment related to the deep geological disposal project (the Cigéo project) for high-level waste (HLW) and intermediate-level long-lived waste (ILW-LL), IRSN organized a workshop in September on "natural fractures in clay formation", attended by 80 international experts. The aims of this seminar were to take stock of the latest findings on the characteristics of fractures in clay soils and to identify what further knowledge, if any, is needed for modeling any associated water flows.



PERIODIC ASSESSMENT OF RESEARCH AT IRSN BY HCERES

Scheduled every five years for public institutions carrying out research activities, this assessment, as provided for by HCERES (High Council for the assessment of research and higher education), is in two parts: the assessment of the research units and the assessment of the Institute as a whole. For the assessment of the research units, the Institute had proposed and obtained the validation of its own external assessment body. This assessment was therefore implemented in 2018 and extended to a five-year plan providing for the successive assessment of the 15 thematic research groups (TRGs) created in line with IRSN's scientific strategy. This concluded in 2022, with the assessment and the submission of the assessment report by each of the dedicated assessment committees of the last six TRGs: dosimetry; containment; radiobiology, radiopathology and therapeutic actions; natural risks, HSS activities; and aging of facilities and systems.

The Institute as a whole was assessed in 2022. To this end, IRSN drew up its self-assessment report and submitted it to HCERES on June 30, 2022. The assessment of the Institute continued with the reception of the Assessment Committee in Fontenay-aux-Roses from November 8 to 10, 2022. Around forty individual or collective interviews of IRSN representatives and its partners were held over these three days. The assessment process will be completed in March 2023 with the submission of the final HCERES report.



IN BRIEF

REINFORCING COMPLEMENTARITY BETWEEN RESEARCH AND EXPERTISE IN THE FIELD OF NUCLEAR SAFETY

IRSN organized for the first time, from November 21 to 23, 2022, a series of encounters for expertise and nuclear safety research staff, as part of IRE (Integration Research Expertise) week: three half-days were devoted to research carried out within IRSN to support, assist, steer and anticipate assessment needs. Topics discussed included the behavior of PWR liners in severe accident conditions, fire propagation path studies, and the evaluation of leakage rates through cracked concrete walls.

The presentations fed into many exchanges between experts and researchers. They highlighted the high degree of collaboration between the teams, helping the scientists to improve their collective knowledge and better understand the context of their work, and the experts to soundly substantiate the conclusions of their appraisals.

These meetings were attended by more than a hundred of the Institute's employees, both in person and remotely.

TRAINING THROUGH RESEARCH

In any research organization, training in and through research fulfills a fundamental mission of transferring the knowledge and skills acquired within its laboratories. For IRSN, training is also a key lever for managing its research programs and their development and, as such, it is given special treatment and attention.

IRSN's training in and through research represents around one hundred doctoral and post-doctoral students, or almost a quarter of the human resources devoted to the Institute's research activities. In 2022, 36 new theses were begun and 25 were defended.

The subjects cover a wide range of scientific disciplines – from physics to biology and social sciences – and the work contributes directly to controlling nuclear risks and protecting the population and the environment against radiological risks. Successive thesis campaigns are leveraged to commit to new fields, explore new scientific concepts or tools, and develop new partnerships.

In addition to its doctoral program, IRSN welcomes several young researchers each year on post-doctoral contracts. Hired for an average of 18 months, they often contribute to scientifically ambitious research projects. In 2022, nine of them joined the Institute's research teams: six in connection with projects selected from the Horizon Europe or ANR calls for tender; one as part of a partnership with the European Space Agency (ESA); and two to carry out work supported by IRSN under its exploratory research program.

Given the special role its doctoral students play in its scientific activity, IRSN is particularly attentive to providing them with the support they need. They benefit from a tailored training curriculum, aimed at facilitating their learning from the research activity and more broadly laying the groundwork for their future career. The support offered includes, for example, workshops on writing scientific articles, advice on setting up a professional network, and training modules on the implementation of open access and openness to society policies, or requirements for scientific integrity.

Skill-building in communication and science popularization is also encouraged. At the end of March 2022, nine doctoral students took part in the "3 minutes for a thesis" eloquence competition organized by the Institute and broadcast live on its YouTube channel as part of the IRSN Thesis Days. Prior to this exercise, the candidates received training in public speaking.

In 2022, the Institute also gave its doctoral students a significant pay rise. Taking into account the objectives set by the research programming law, IRSN decided to increase this pay to €2,300 gross per month from September 2022, representing a pay rise of over €200.

At the same time, IRSN continues to boost its capacity to supervise doctoral students by encouraging its researchers to pursue accreditation to become research directors (HDR). Five HDRs were admitted in 2022, bringing the number of HDRs in the Institute's ranks to 69.



Marie Frèrejacques,
Doctoral student winner of the 2022 "3 minutes for a thesis" competition with "An almost perfect toxic crime"

"3 minutes for a thesis" is an exercise that I would recommend to all doctoral students! It allows you to take a step back from your work and couch it in layman's terms, so that you can explain what you do to your nearest and dearest, not to mention learning to talk in public. This is a really useful skill, including at scientific congresses where it is important to contextualize your discourse for participants whose areas of activity may be far removed from your own. It helps bring a presentation to life.



Raphaël Gavart,
PhD student

It's not easy to sum up three years of work in three minutes! You need to find the right level of vulgarization, and strike a balance between simplification and the development of complex notions. But it helps you learn how to manage your stress and to acquire effective public speaking skills. We were given training that enabled us to work on simplifying content as well as speaking in public. It's a great learning experience.

SCIENTIFIC PARTNERSHIPS



STRENGTHENING ACADEMIC PARTNERSHIPS

To consolidate its position in the French scientific landscape and to increase support for its subjects of interest, IRSN has been working for several years on strengthening ties with the academic world. In addition to the long-standing relations it has with nuclear stakeholders and in particular the CEA, it has chosen to refocus its partnership strategy on a privileged relationship with the CNRS, Paris-Saclay University and Aix-Marseille University.

A common roadmap was established with the CNRS in 2022, in line with the framework agreement renewed at the end of 2020 between the two organizations. It entails stronger collaboration on six themes: alteration of materials, components and structures; earthquakes and ground-structure interactions; cross-disciplinary *in situ* research in the field of the environment; new nuclear techniques for healthcare; sensors and metrology; software platforms and simulation. Two cross-disciplinary fields are also concerned: sensors, measurements and their processing; codes and scientific modeling platforms. A specific management system has been set up to ensure the smooth running of this collaboration. Its objective is to combine the CNRS's fundamental research potential and IRSN's applied research capabilities to underpin the assessment of nuclear and radiological risks and contribute to meeting energy and healthcare challenges.

As for Paris-Saclay University, a framework agreement was signed in March. More specifically, it covers the fields of research involving the Institute's teams in the Île-de-France region: healthcare, geosciences, and certain aspects of nuclear safety (neutron physics, aerosol physics, behavior of materials). In terms of training, the framework agreement enables the work of IRSN researchers to be optimized in the teaching programs of Paris-Saclay University and raises awareness of the Institute among students. Finally, the framework agreement provides for a shared approach to research facilities between the two entities, including future equipment.

Concerning relations with Aix-Marseille University, the Cadarache research teams have been working closely with three of the University's institutes (ISFIN, ITEM and *Institut Sciences de l'Océan*), with additional contacts having also been established at an institutional level to prepare the implementation of a general collaboration framework in 2023.

HORIZON EUROPE: IRSN SELECTED FOR MANY PROJECTS

Euratom research projects carried out under the *Horizon Europe* program constitute an essential collaborative framework for IRSN and various European partners. In the field of protection of the public, the workforce, patients, and the environment against ionizing radiation, for example, the CONCERT-European joint program, carried out under the eighth H2020 framework program, has obtained results that underpin today's PIANOFORTE research partnership. Selected at the beginning of 2022 by the European Commission, PIANOFORTE is a large-scale project with 58 partners from 25 Member States of the European Union. Coordinated by IRSN, these partners share a common objective: taking the next step in the construction of Europe-wide radiation protection. In this spirit, the consortium running the project proposes an ambitious research program in multiple areas, such as the side effects of treatments using ionizing radiation, the differences in individual radiosensitivity, and resilience in crisis and post-accident situations.

PIANOFORTE is one of the two major partnerships led by the Institute, alongside ASSAS, a project designed to demonstrate, in the field of nuclear safety, the feasibility of a severe accident simulator using the ASTEC integral code. Developed and used by IRSN for its studies and assessments, ASTEC has become the benchmark European code in this field.

These two flagship projects are among the 15 proposals drawn up with the participation of IRSN and submitted to the European Commission, of which 11 were selected. This is a very satisfactory result and represents an allocated budget of €4.2 million for the Institute.



SAFETY RESEARCH

The safety research conducted by IRSN in 2022 was largely devoted to the topic of severe accidents, with the launch of projects such as ASSAS in the field of simulation, the continuation of projects such as PERFROI focusing on loss of cooling accidents, and the closure of programs such as MITHYGENE and SAMYCHO in the area of hydrogen risk. Most of these projects are based on the use of different IRSN experimental platforms located in Cadarache (Bouches-du-Rhône).

The year's highlights also included research into the safety of innovative concepts, such as passive safety systems, and studies in human and social sciences, for example on the conduct of complex projects and resilience.

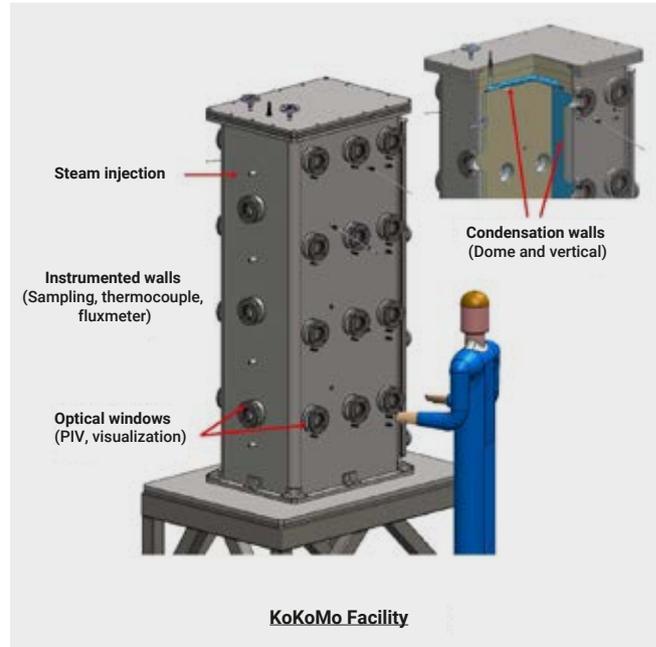
SIMULATION OF SEVERE ACCIDENTS: IRSN COORDINATES THE ASSAS PROJECT

Launched in November 2022 as part of the *Horizon Europe* research program, the project entitled ASSAS (Artificial intelligence for Simulation of Severe AccidentS) dovetails with IRSN's logic for developing the ASTEC code for assessing an accident's source term. ASTEC integral code has become the European benchmark for the modeling of severe accidents.

With ASSAS, IRSN and its partners intend to go further by demonstrating the feasibility of extending nuclear simulators to the field of severe accidents, based on the ASTEC code. Plus, the prototype developed as part of the project can be used to train students, experts, and non-experts in nuclear energy. A simplified generic pressurized water reactor (PWR) model, like the ones used in the United States and Western Europe, will be available for training purposes. It will also include a graphic interface for controlling the simulation – in real time, or even in accelerated mode for certain phases of the accident – and for viewing the main phenomena unfold in a given severe accident scenario, including the phases inside and outside the vessel.

Drawing on the experience gained by the 13 project partners in severe accident modeling, nuclear reactor behavior simulation and data science, ASSAS will mobilize effective programming and parallelization techniques as well as artificial intelligence to improve ASTEC's performance. The learning base, made up of severe accident sequences and used for machine learning (automatic training of artificial intelligence algorithms), will be shared in an open-source framework.

The simulator prototype will be the first step in the development of analytical or full-scale simulators extended to severe accidents. These can be used in the future to develop emergency response guides for severe accidents, to evaluate the performance of new safety systems, and to train operators in their use.



RESEARCH DEDICATED TO PASSIVE SAFETY SYSTEMS: IRSN LAUNCHES THE PASTIS PROJECT

The accident at the Japanese Fukushima-Daiichi power plant in March 2011 demonstrated, in certain extreme situations, the vulnerability of safety systems using equipment whose operation requires an external energy source or human intervention (particularly for reactor core cooling). Nuclear reactor designers are increasingly focused on this vulnerability, and propose the implementation of so-called "passive" safety systems which have the advantage of being controlled by natural phenomena – including thermohydraulics – generated by events occurring in a reactor, particularly in abnormal situations.

These systems are being built into the plans for most new SMR (Small Modular Reactor) concepts to manage potential accident situations, preventing them from turning into more severe accidents. Therefore, IRSN decided in 2022 to launch a thermohydraulic research program for passive safety systems called PASTIS (Passive Systems ThermalHydraulic Investigations for Safety) in order to be able to evaluate the performance of these systems, when the time comes, with regard to safety requirements.

While pressurized water reactors already use certain passive safety systems – such as nuclear fission control rods, autocatalytic recombiners or safety injection system batteries –, some SMR concepts base their main safety system on them. The performance and reliability of these passive systems, as well as the physical phenomena on which they are based, must therefore be confirmed and investigated in the light of any accidents or incidents that may occur.

The research project designed by IRSN, and which benefits from a State subsidy managed by the National Research Agency under the France 2030 plan, includes two phases. In a first phase, from 2022 to 2025, an experimental platform composed of two facilities will be developed: a thermohydraulic loop called ALCINA (French acronym for "Analysis of natural circulation"), simulating the principle of a safety condenser and dedicated to the analysis of parameters influencing the natural two-phase circulation, and an enclosure cooled by a condensation wall called KoKoMo ("COn densation in a COn tainment MO del facility"), simulating the principle of a cold wall condenser and dedicated to the study of convective movements and coupled condensation-stratification effects in a submerged containment structure in a pool in an accident situation. The second phase of the project, starting in 2026, within the framework of international research projects, will be devoted to conducting experimentation campaigns on this platform, as well as developing thermohydraulic models and validating codes, for later use by risk assessment experts.

SUCCESS OF THE NEW PERFROI/COAL TEST CAMPAIGN

As part of the PERFROI project, a third COAL test campaign was completed in 2022, providing data on the resistance of fuel rods that have been pressurized and deformed by heating following a loss-of-coolant accident (LOCA) where the reactor core is unable to be cooled. Conducted using an experimental device developed by IRSN and installed in a thermohydraulic loop provided by STERN Laboratories in Canada, this third campaign will add to the experimental database (which compiles the results of 82 tests in total). The results of these tests will make it possible to validate and improve DRACCAR software, developed by IRSN to simulate the behavior of nuclear fuel during a LOCA and used in the assessment process.

Performing high temperature testing was one of the technological challenges of the COAL program. Special heating rods were designed for this purpose, enabling a total of eight experiments to be carried out above 1,000°C without any damage to the rods and with little loss of thermocouples: a noteworthy technical feat!

FIRE INVESTIGATION: CLOSURE OF THE PRISME 3 PROJECT

The PRISME 3 project is the third phase of PRISME's international research program, dedicated since 2006 to studying fires and their spread vectors in confined and ventilated premises typical of a nuclear facility. PRISME 3 testing was conducted in the GALAXIE experimental platform facilities, implemented by IRSN in Cadarache (Bouches-du-Rhône), to gain more in-depth knowledge in three areas: the spread of smoke and fumes during a fire in a multi-compartment facility, the spread of an electrical cabinet fire to nearby electrical cabinets, and the spread of fire along cable trays.

The closing seminar for this project, run since 2017 under the aegis of the Nuclear Energy Agency of the Organization for Economic Cooperation and Development (OECD/NEA), was held at the end of October in Cadarache and attended by 12 partners from eight countries. Discussions around the PRISME 3 project summary report showed that while some results – such as the identification of different fire propagation paths between an electrical cabinet and other cabinets – were directly transposable for safety assessments, others highlighted the current limitations of simulation tools and the need to significantly increase the scope of their validation areas. This is the role assigned to the *Fire risk Assessment through Innovative Research (FAIR)* project led by IRSN, which is scheduled to be launched in 2023, again under the aegis of the NEA.



COMMISSIONING OF THE FUEL+ SOFTWARE PLATFORM

The objective of the FUEL+ software platform is to model the behavior of nuclear fuel under normal and abnormal (incident / accident) operating conditions in reactors as well as during storage in spent fuel pools and transport for reprocessing. Designed along the principle of pooling and coupling different software solutions developed by IRSN, such as SCANAIR and DRACCAR, the FUEL+ platform makes it possible to model all thermomechanical, thermochemical and thermohydraulic phenomena occurring in and around nuclear fuel and its cladding on the scale of the fuel rod, the assembly, or the reactor core.



CLOSURE OF THE MITHYGENE AND SAMHYCO-NET PROGRAMS

Two IRSN research projects related to the hydrogen risk were completed in 2022. Funded by the Government as part of the Nuclear Safety and Radiation Protection Research Program (RSNR), the first, called MITHYGENE, made it possible to develop and qualify under "severe accident" conditions a prototype for measuring the concentrations of gases in the containment atmosphere in phases inside and outside the vessel during a severe accident in a reactor. It also involved implementing and analyzing tests on the impact of the location of passive autocatalytic recombiners, hydrogen combustion, and flame-structure interaction. These test results have had several impacts: enabling the operator, EDF, to consolidate the rules for placing recombiners in the containment, improving the tools used to assess the hydrogen risk, and establishing recommendations for better management of spray cooling in the event of a severe accident.

The second, called SAMHYCO-NET, is an international project coordinated by IRSN and backed by the European NUGENIA research platform for generation II and III reactors. It has helped improve knowledge of the behavior of recombiners subjected to atmospheres representative of the late phases of a severe accident, during the interaction between corium and concrete in the reactor pit, as well as to the combustion of hydrogen and carbon monoxide mixtures.

MITHYGENE and SAMHYCO-NET have made a major contribution to underpinning the competences of IRSN and its partners in the field of hydrogen risk.

CRITICALITY RESEARCH: THREE MAJOR ADVANCES FOR THE PRINCESS PROJECT

Conducted within the framework of international partnerships, the PRINCESS project was developed to acquire experimental data in neutron physics and criticality. To this end, three major experiments were conducted in the United States in 2022. The first concerns neutron noise measurements, which used the IRSN detection chain for the first time. The second consists of a dosimetry exercise providing practice in assessing the doses received by workers in the event of a criticality accident. The last is a criticality experiment carried out specifically for the needs of IRSN, building on the MIRTE program which was carried out in France from 2008 to 2013 to learn more about the neutron characteristics of certain nuclides present in the structural materials used in the nuclear fuel cycle.



Céline Poret,
Researcher in human
and social sciences



Alexandre Largier,
Researcher in human
and social sciences

RESEARCH IN HUMAN AND SOCIAL SCIENCES: INVESTIGATING COMPLEX PROJECT MANAGEMENT AND RESILIENCE

Changes in the industrial environment have led IRSN to focus on the issues of managing complex projects and resilience in the fields of nuclear safety and radiation protection from the perspective of the organizational and human factors. Céline Poret and Alexandre Largier, researchers in human and social sciences at the Institute, explain.

What questions do you think are raised by the impact of transformations seen in the industrial environment from the point of view of managing projects in the nuclear sector?

Céline Poret *To address these developments, which demand reactivity and flexibility, the various industrial sectors have built process-based organizations. This means working in project management mode and cooperating within the framework of supply chains (suppliers, subcontractors, etc.). These "cross-cutting" organizational configurations call into question the hierarchical and functional structure of traditional organizations and raise questions in human and social sciences. One of these questions we need to explore is how the different dimensions of performance - including nuclear safety, the safety of patients and radiation protection - are constructed and maintained in organizations characterized by the multi-distribution of activities: spatial, temporal, multi-enterprise, etc.*

How is IRSN addressing this new complexity?

CP *Through our "Management of complex cooperations" research program, we are trying to understand the mechanisms behind the fact that the interactions between various actors and the end result in terms of performance cannot be expressed as a simple sum of contributions. This program includes projects that focus both on various organizational configurations and different performance dimensions. Some organizational configurations feature activities that overlap*

in a distributed manner over space and time, such as the manufacture of large forged and molded parts or the preparation of radiation therapy treatments, while others feature activities that overlap in the same space, such as the northern extension of line 14 of the Paris Metro or the CIGEO project for geological disposal of nuclear waste. Therefore, some projects are designed to study how nuclear safety is constructed and maintained in these organizations, while others focus on radiation protection and/or patient safety.

What is meant by "resilience" in the nuclear domain?

Alexandre Largier *The notion of resilience, albeit relatively recent in the field of risk control, is increasingly present in the day-to-day activities of companies and, more broadly, of society as a whole. Activities in the fields of nuclear safety and radiation protection are no exception. Resilience, which has become an important concept in risk management, involves a paradigm shift which will extend beyond risk prevention approaches. In order to make the greatest possible contribution to managing these risks, we must identify the conditions under which this concept needs to be mobilized and how it ties in with concepts such as robustness and anticipation, or other concepts developed in human and social sciences, such as adjustment or adaptation. In July 2022, IRSN took part in the 56th congress of SELF – the French-language Ergonomics Society, devoted to vulnerabilities and emerging risks – where it presented an analysis whose main conclusion was that the spectrum of resilience needed to be reduced in order for its use to be pertinent. In the field of nuclear safety, resilience could be defined as the capacity of a socio-technical system to adapt to a range of abnormal, degraded, and critical situations, by developing anticipatory, response, and recovery capacities at different organizational levels, for dealing with unexpected events.*

HEALTH-RELATED RESEARCH

2022 was a year of major advances on a European scale in matters of radiation protection, with the launch of the PIANOFORTE partnership project and the publication, as part of the MEDIRAD project, of recommendations for strengthening radiation protection for patients and medical staff. Other highlights include the continued rollout of new methods of administering stable iodine to better protect the population in the event of releases of radioactive iodine.

PIANOFORTE, A SHARED VISION OF THE FUTURE OF RADIATION PROTECTION

Selected by the European Commission and coordinated by IRSN, the PIANOFORTE research project marks a new stage in the construction of radiation protection for Europe. With 58 partners representing 22 European Union countries, the United Kingdom, and Norway, and coordinated by IRSN, it is co-financed by the EURATOM program and the Member States.

This project embodies a shared vision of the future of radiation protection within the framework of *Horizon Europe*, the EU framework program for research and innovation for the period 2021-2027. PIANOFORTE succeeds the European CONCERT program for radiation protection research and translates the common vision of radiation protection bodies and platforms into programmatic terms.

PIANOFORTE will contribute to European policies on priority topics such as fighting cancer, health protection in the face of environmental risks, and improving anticipation and resilience in disaster situations. To ensure effectiveness, multidisciplinary research will be favored, and research projects will focus on clearly identified priorities and be selected through calls for proposals.

In fact, between 2023 and 2025, three calls for proposals will be organized. Open to the entire European radiation protection research community, these will focus on four themes:

- Improving radiation protection for patients in relation to the use of ionizing radiation in the medical field
- Better understanding the variability of the individual response to exposure to ionizing radiation
- Studying the mechanisms at work during chronic exposure to low doses of ionizing radiation
- Improving anticipatory and resilience capacities in nuclear or radiological crisis situations and post-accident management.

The involvement of stakeholders (authorities, civil society, radiation protection practitioners, experts, etc.) will be requested and endorsed when defining the scientific topics that will be the subject of the calls for proposals. Another goal of this partnership is to build bridges with "non-Euratom" research activities carried out on the European level, especially in the field of healthcare.

The PIANOFORTE kick-off meeting was held on June 14 and 15, 2022. It was attended by some 100 participants, reflecting the ambitious scope of this program. This meeting allowed the partners to start working on the methodology in order to prioritize the research themes that will lead to calls for proposals, the first of which is to be published in April 2023.

MEDIRAD: RECOMMENDATIONS FOR BETTER RADIATION PROTECTION

Launched in 2017 and scheduled to run for five years, the European MEDIRAD project has led to the development of recommendations for optimizing the use of ionizing radiation in the medical field and improving radiation protection for patients and healthcare professionals.

Financed under the EURATOM H2020 research program for five years and coordinated by ISC Global (Spain) and the University of Paris Descartes, the European MEDIRAD project mobilized 33 partners from 14 European Member States.

Its purpose was to narrow the gap between scientific and medical communities in the field of medical radiation protection research and to optimize the use of ionizing radiation in radiotherapy, nuclear medicine, medical imaging, and interventional radiology. The project also promoted links between science, medicine, and society to improve quality of life for patients and better protection for healthcare professionals.

As a major contributor to this project, IRSN participated in MEDIRAD's work in three areas of medical applications of ionizing radiation:

- In radiotherapy, where research focused on assessing the risks of cardiac toxicity associated with radiotherapy for breast cancer and optimizing practices
- In interventional radiology, and more particularly radiation protection for healthcare professionals and practice optimization.
- In medical imaging, with the assessment of the cancer risk associated with pediatric computed tomography.

Based on their scientific results, IRSN coordinated the development phase of a set of radiation protection recommendations with support from stakeholders: patient associations, healthcare professional associations, and competent radiation protection and industrial authorities in the medical sector. These recommendations are divided into four areas: the consolidation of "patient" databases at the European level; the optimization of diagnostic or therapeutic protocols involving radiation; optimization for the radiation protection of patients and healthcare staff; and European avenues of research for radiation protection in medicine.



IN BRIEF

STABLE IODINE PROPHYLAXIS AND POPULATION PROTECTION

As part of the PRIODAC research project – initially run under the RSNR program and designed to determine new methods of administration for stable iodine (KI-65 mg) to better protect the population in the event of repeated releases of radioactive iodine –, an extension application for the marketing authorization (MA) for repeated administration in the category of pregnant women was filed in October 2022 by the Central Pharmacy of the Armed Forces. Coordinated by IRSN, this project has already led to an initial amendment of the MA for repeated administration for up to 7 consecutive days for people over 12 years of age.

ENVIRONMENTAL RESEARCH

In 2022, IRSN environmental research featured projects addressing a wide range of issues: the impact of environmental contamination on the marine environment and terrestrial ecosystems following a nuclear accident, the ecotoxicology of radionuclides, the management of radioactive waste.

GEOLOGICAL DISPOSAL: IRSN LAUNCHES VSEAL EXPERIMENTATION

Within the framework of its expertise missions for the CIGEO project on the geological disposal of high-level and intermediate-level long-lived radioactive waste (HL-ILW-LL), IRSN is conducting research focusing on the durability of seals. The objective of this research is to enable IRSN teams to assess, as part of the assessment of the safety dossiers drawn up by Andra (French National Agency for Radioactive Waste Management), how effectively the selected sealing techniques ensure a crucial containment function for this type of waste over a very long time period.

In 2022, the Institute initiated the VSEAL project, conducted in its underground research laboratory in Tournemire (Aveyron). The aim of this project is to observe how airtight a seal remains over a period of fifteen years, studying the impact of run-off water and the hydrogen that would be produced by stored waste. This seal is made from a type of clay with high swelling capacity called bentonite, the material chosen to seal the CIGEO facility at the end of its operating period.

VSEAL illustrates IRSN's ability to translate scientific and technical questions into a research program incorporating technological trials, effectively preparing for future assessments.



CLOSURE OF THE AMORAD PROJECT: THE MAIN TAKEAWAYS

The aim of the AMORAD project, launched in France in 2013 as part of the Nuclear Safety and Radiation Protection Research (PIA RSNR) program, is to improve the models for assessing the dispersion of radionuclides in the environment and their impact on the marine environment and terrestrial ecosystems following an accident such as that of Fukushima-Daiichi. In addition to several national partners (Andra, BRGM, CNRS, EDF, Ifremer, LSCE, Universities of Bordeaux, Pau, Toulon, Toulouse and Versailles), the project involved the Japanese University of Tsukuba.

Two areas of research were selected for the project. The first focused on the marine and coastal dispersion of sedimentary particles and dissolved radionuclides, their transfer into the food chain, and the development of approaches to assess the environmental and economic vulnerability of coastal areas in the presence of release. The second addressed the impact of contamination on terrestrial environments, focusing on the soil-tree-forest system and the transfer of radionuclides from the soils of a drainage basin to the sea.

An extension of the project, called AMORAD II, was launched in 2019 with two objectives. The first involved acquiring additional data from Fukushima and French forests in order to move forward on a soil-tree transfer model. The second objective was to develop a multi-model approach to assessing the costs associated with the loss of economic resources following a nuclear accident. The closing seminar, attended by the 13 partners in 2022, enabled us to draw up our conclusions and identify some major takeaways.

Concerning the simulation of radionuclides dispersion in the terrestrial and marine environment along with the evaluation of the associated concentrations, AMORAD made it possible to refine existing models and create new ones. Examples include: more realistic simulation of river delta or estuary depositions; integration of the medium-term effect of deposition processes and re-suspension in coastal zone sediment transport models; creation of an expert system to trace the possible origin of a release in the event of abnormal radionuclide measurements in a given area; development of a model for assessing the flows of radionuclides that can leach from a drainage basin to a river after atmospheric fallout, etc.

Concerning the assessment of the costs of an accident, another major part of the AMORAD project, two assessment modules were created describing the economic losses sustained by the timber and offshore fishing sectors in the event of post-accident releases and/or fallout. The results highlight for the first time the extent of economic damage that could be associated in particular with the losses of ecosystem-dependant services (hunting, harvesting, drinking water) in the event of an accident, and which will now need to be assessed more precisely.

Certain AMORAD results can be leveraged for recommendations to the public authorities on the post-accident management doctrine of a nuclear accident.



RADIOACTIVE ENVIRONMENTAL CONTAMINATION: WHAT ARE THE LONG-TERM EFFECTS ON BIODIVERSITY?

Contamination of the environment with radioactive substances and the associated risks to biodiversity are the subject of extensive societal and scientific debate. Many unknowns contribute to controversies on the ecological effects of this type of contamination, and therefore delay implementation of environmental protection criteria. In this context, one of IRSN's missions, in its capacity as a public expert in research and on nuclear and radiological risks, is to provide scientific evidence to support arguments in this debate. That is why, in June and July 2022, the Laboratory of Ecotoxicology of Radionuclides (LECO) conducted, in the Fukushima Prefecture, field and laboratory research, in partnership with the Institute of Environmental Radioactivity (IER) of the University of Fukushima.

A first project led by IRSN, entitled KERO, aims to understand and measure the long-term consequences of radioactive contamination of the environment on wildlife, through a sentinel species, the Japanese tree frog (*Dryophytes japonicus*). Several institutes and universities (Aix-Marseille, Fukushima, Hiroshima, Lyon 1, Paris-Saclay) are working together on this project which is financed by IRSN as well as through other funding programs (NEEDS, ECCOREV, EC2CO, ERAN Japan, etc.). The project addresses several questions: what are the impacts of radiation contamination on these frogs (physiology, behavior, etc.)? How can these individual effects lead to population-wide impacts? How are these populations developing in these regions? Are they able to adapt? Such evolutionary issues are still neglected by the scientific community despite strong expectations from experts in the field of environmental regulation and from the general public. Indeed, several years after the Chernobyl and Fukushima nuclear accidents, the same question often arises: how is the wildlife actually "doing"? How are species developing in these radiation-contaminated territories?

A second project, called BEERAD, looks at the western honeybee, *Apis mellifera*, from several scientific perspectives (ecological, economic and societal). This choice reflects the importance of the services provided to humans and ecosystems, especially the bee's role in the pollination of flowering plants. Financed by the ANR as well as by other programs (ECCOREV, ERAN), the BEERAD project is coordinated by IRSN with the participation of the INRAE center in Avignon and the IER. This project uses a multidisciplinary approach to gain deeper knowledge of the effects and action mechanisms of ionizing radiation on the physiology and populations of the western honeybee in the context of chronic exposure (exposure of a significant duration compared to the lifetime of the organisms exposed) at low dose rates. This involves conducting experiments, one, in the laboratory, using IRSN's Micado-Lab and MIRE irradiation platforms, and two, in the field, by installing beehives in the Fukushima Prefecture, which will be monitored throughout two seasonal cycles.

KERO and BEERAD are two original and innovative research projects. They will provide new-found knowledge to help reduce current uncertainties in ecological risk assessment and to evaluate the robustness of environmental radiation protection criteria to ensure the good ecological condition of ecosystems.



Elisabeth Salat,
Deputy head of the radioactive waste management and transfers in the geosphere department (SEDRE)

RADIOACTIVE WASTE MANAGEMENT: IRSN, HOST OF THE ANNUAL MEETING OF THE EUROPEAN EURAD PROGRAM

Radioactive waste management is one of the areas in which IRSN is pursuing international cooperation, namely within the framework of the European Joint Research Program, EURAD. Elisabeth Salat, deputy head of the Institute's Radioactive Waste and Transfers in the Geosphere department (SEDRE), reviews the program's objectives and recounts the highlights of the annual meeting, hosted by IRSN from March 28 to 30, 2022 in Fontenay-aux-Roses (Hauts-de-Seine).

What is the European EURAD program?

It is a joint research program worth around €60 million, launched in 2019 for a period of five years by the European Commission who also funds 50% of the program. This program has 51 beneficiaries – including IRSN and Andra, the project coordinator – from 23 European countries, all eager to extend their cooperation in terms of research into management and, especially, disposal of radioactive waste. To achieve this, EURAD is based on the implementation of a sustainable research and development program, and leveraging and transferring previously acquired knowledge. The program also promotes mutual understanding and trust between, on the one hand, the scientific and technical partners, and, on the other, stakeholders in civil society.

Who are the main partners?

They can be divided into three broad categories: first, radioactive waste management bodies, such as Andra in France, responsible for implementing solutions for radioactive waste disposal. Then there are the technical assessment bodies, such as IRSN, which carry out research activities to reinforce the scientific and technical foundations of their expertise missions which provide support for decisions made by the public authorities. Third, there are the research organizations and universities working to varying degrees on the challenges of radioactive waste management.

What are the main conclusions of the annual meeting held at IRSN?

I would like to point out that this meeting, organized in collaboration with Andra, was the first opportunity for all program partners to meet in the same place, after the health crisis. The main theme of this event was knowledge management: how to capitalize on knowledge in the field of radioactive waste management, share it, and identify the areas in which more in-depth investigation is required. A number of topics emerged from our discussions, such as the use of "digital twins" to centralize the results of various research projects. In fact, this topic will be developed further and integrated into future research programs.



NUCLEAR SAFETY EXPERTISE

As a public expert on nuclear and radiological risks, IRSN assesses the safety of nuclear facilities – reactors, fuel cycle plants, laboratories, research or radioactive waste disposal facilities – at each stage of their life cycle, from design to decommissioning. The results of its research programs and studies, the analysis of feedback from events occurring in facilities and transport, and the lessons learned from previous safety assessments feed into its expertise work.

In 2022, IRSN worked on several major expertise files, such as identifying the main challenges of the 10-year nuclear safety assessment, the Flamanville EPR reactor, following up the generic periodic review for 900 MWe reactors, the EPR2 project, fuel cycle facilities and dismantling, R85 transportation packaging, and feedback on fuel behavior in reactor over the past decade. Yet the most important files remain, one, the periodic safety review of the nuclear fleet – at the generic review stage for the 1,300 MWe reactors (RP4-1,300) and the ten-yearly inspection for the 900 MWe series reactors (VD4-900) – and, two, work related to the analysis of stress corrosion damage to pipes connected to the main primary circuit of several EDF reactors; a phenomenon which has led to the prolonged shutdown of around a dozen of them.

NUCLEAR SAFETY: IRSN IDENTIFIES THE MAIN ASSESSMENT CHALLENGES FOR THE NEXT 10 YEARS

In 2022, IRSN published its safety expertise strategy for the next 10 years. The Institute recently dealt with several major safety dossiers relating to nuclear reactors (4th safety review of the 900 MWe reactors, commissioning dossier for the Flamanville 3 EPR), fuel cycle facilities (future EDF centralized spent fuel pool), research laboratories, and the transportation of nuclear materials. In a rapidly changing context, IRSN now faces new challenges: aging of facilities, relaunch of nuclear power, climate change, etc. At this pivotal time, it was important to review the previous safety expertise strategy and prioritize the issues. This new strategy, applicable to all civil nuclear facilities, is broken down into four main areas.

The first area involves improving operational safety, with regard for example to training field operators in the proper use of safety mechanisms, or improving the reliability of interventions. This includes in-depth analyses of how well operating standards are assimilated and applied as well as feedback on operating experience.

The second area involves improving the design safety of existing facilities, based on a global vision of safety. This requires the stabilization of safety standards for existing facilities and monitoring implementation in the field, while taking into account consequences of climate change, and analyzing the conditions for keeping older facilities in operation. Encouraging operators to dispose of old waste and rapidly dismantle shut-down facilities is also part of this priority area.

The third area concerns future facilities. In particular, this involves taking a position on the safety objectives and requirements to be adopted, taking into account best practices and doctrines at international level, and taking onboard feedback acquired on the most recent projects, implementing an approach consistent with the stakes. In addition to EPR2, IRSN is preparing expertise for new reactor concepts, such as small modular reactors (SMR) which implement innovative technologies.

Finally, the last, more general area involves being able to adapt and anticipate. Faced with ongoing digitalization for operators, the possibilities offered by artificial intelligence technologies, innovative study methods, as well as the need for more global approaches to safety – including a comprehensive understanding of the socio-technical system and organizations –, the business of safety expertise will have changed markedly by 2030. IRSN is busy preparing for this.



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TECHNICAL OPINIONS
AND REPORTS
TO THE NUCLEAR
SAFETY AUTHORITY

VD4-900: IRSN REPORTED ON EXTENDING THE OPERATION OF THE BUGEY 2 AND TRICASTIN 2 REACTORS

After the generic review of all reactors in the 900 MWe series (RP4-900), the ten-yearly inspection of each of these reactors (VD4-900) was the object of a periodic review conclusion report (RCR) drawn up by EDF. In this document, the operator rules on the facility's compliance with its safety standards and, as such, draws up a summary of any modifications made on or planned for the facility in order to correct any non-compliant findings or improve facility safety.

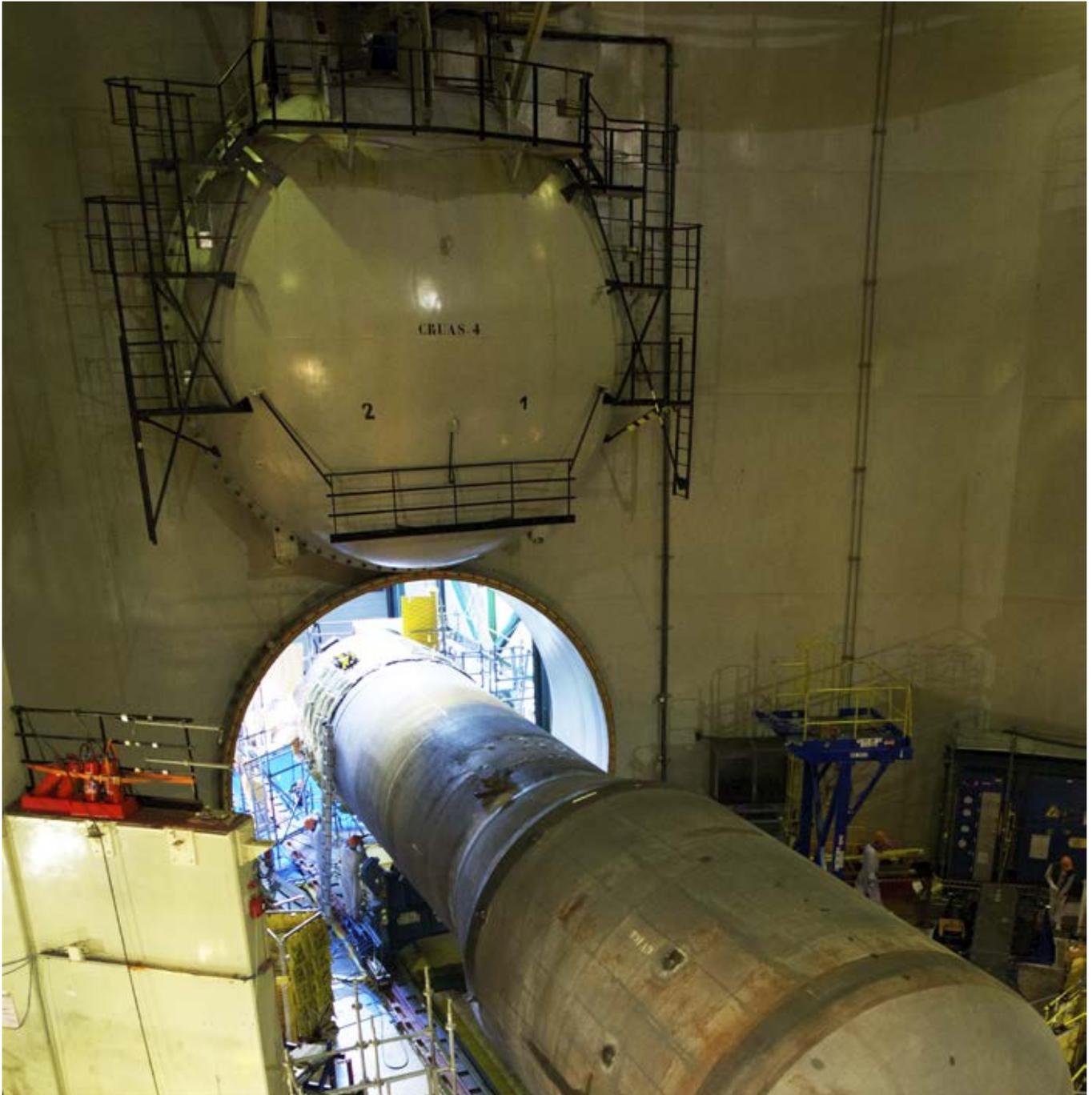
At the request of the ASN, IRSN examined the various themes of this periodic review, such as facility compliance, its ability to continue operating beyond 40 years, control of potential consequences linked to its aging, protection against the effects of external stresses, civil engineering, condition of the reactor vessel, qualification of materials in accident conditions, and progress in deploying "post-Fukushima" measures. For each report, nearly a thousand pages were analyzed to draft the technical notice submitted by the Institute to the ASN. In 2022, the Institute published the technical notices relating to the periodic reviews of the No.2 Bugey and No.2 Tricastin reactors.

IRSN CONTINUED EXPERTISE OF THE 4TH PERIODIC REVIEW OF 1,300 MWE REACTORS

After carrying out the fourth periodic review of the 900 MWe reactors (RP4-900), IRSN continued in 2022 with that of the twenty 1,300 MWe reactors (RP4-1,300) commissioned by EDF from the mid-1980s. This large-scale project, which began in 2019 with the examination of the safety guidance files prescribing the subjects of interest to be examined during the generic phase of the RP4-1,300, has continued since 2021 with the examination of the first safety dossiers submitted by EDF. This generic phase will be completed by the end of 2024 at which time the Institute will submit a technical notice to the ASN, enabling them to take an informed stance on the ability of 1,300 MWe reactors to continue operating beyond 40 years.

IRSN's experts drew on the conclusions of the assessments carried out as part of RP4-900, submitted to the ASN at the beginning of 2021, to prioritize the subjects to be examined with regard to safety issues, taking into account the main differences in design between the 900 MWe and 1,300 MWe reactors. One of these concerns the double containment shell of the 1,300 MWe reactors, for which the Institute has launched a research program on the behavior of the leaktight liners on the underside of the reactor building in the event of a serious accident. IRSN will also examine the additional safety studies relating to the loading of six of these reactors with uranium-plutonium mixed oxide (MOX) fuel, which constitutes a major change in relation to their design baseline.

Finally, the RP4-1,300 expertise will also be an opportunity to focus on highly complex topics such as the potential impact of internal and external stresses (fire, explosion, heatwave, internal flooding, etc.) and the deployment of the latest "hard core" equipment, incorporating the lessons learned from additional safety assessments carried out on nuclear facilities following the Fukushima-Daiichi accident.



IRSN'S TECHNICAL NOTICE ON THE BEHAVIOR OF REACTOR EQUIPMENT ACCESS HATCH SEALS

As their name suggests, the access hatches allow various pieces of equipment to enter and exit the containment of the reactor building. These hatches ensure the containment of radionuclides in the reactor building, particularly in the event of a serious accident, by compressing the seals when they are closed. IRSN studied the behavior of these seals under the combined action of irradiation, temperature, pressure, and water vapor. In the technical notice that it issued on this basis in 2022, the Institute asked EDF to complete its sealing demonstration in severe accident conditions, which has not yet been done for any of the reactor access hatch seals of the fleet in operation.

IRSN INVOLVEMENT IN THE SAFETY ANALYSES OF INNOVATIVE SMALL MODULAR REACTORS

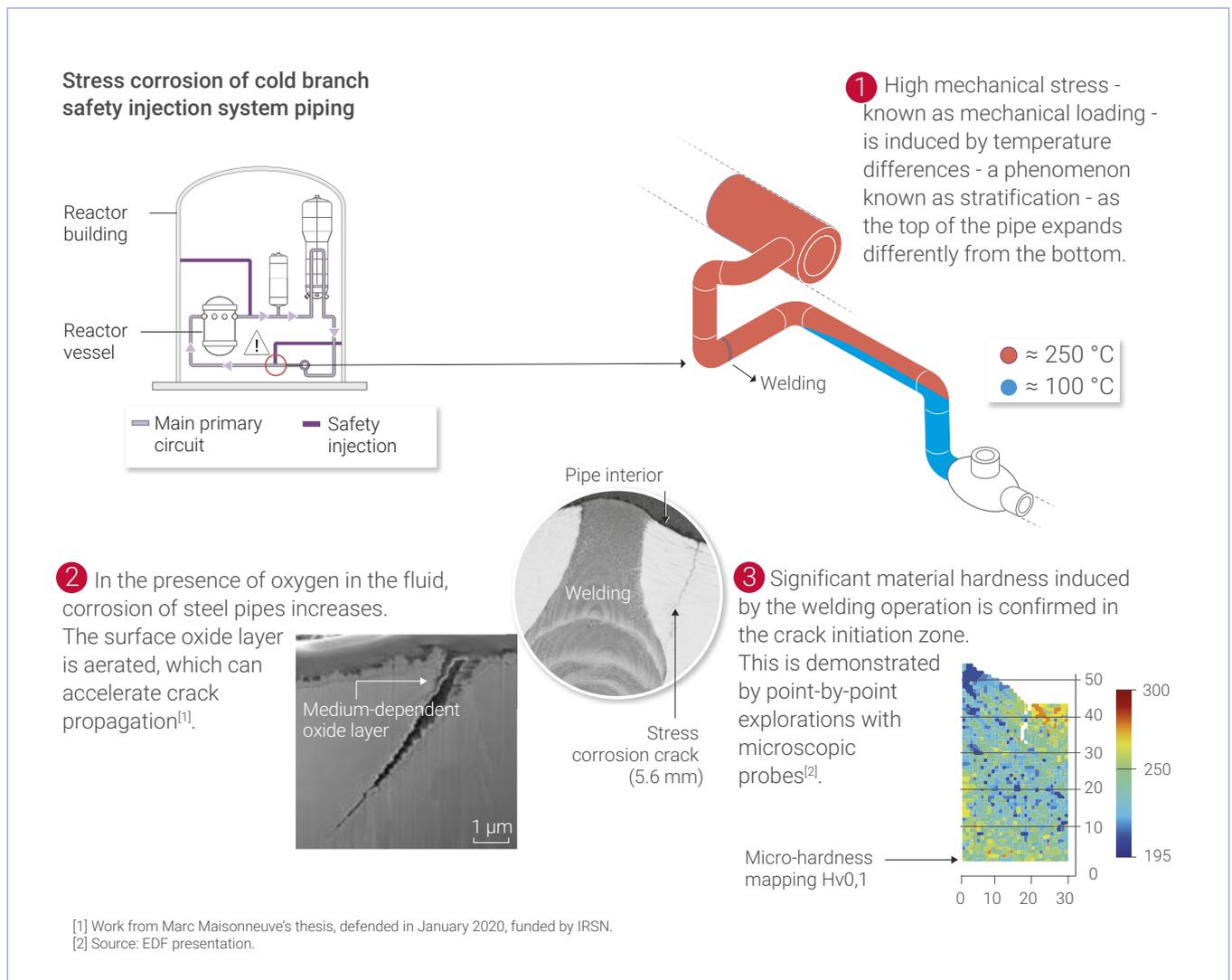
Jimmy is a high temperature calorogenic microreactor project developed by the company Jimmy SAS. At the request of the ASN, IRSN assessed in 2022 whether or not adequate information had been received to conduct an expertise of the safety options. This analysis showed that the main safety options (core, barriers, main accidents, etc.) were addressed in the dossier, but that their assessment would require additional information from the designer. IRSN's analysis was therefore limited to the technical subjects underpinning the Jimmy concept – such as the reactor core and primary circuits – with a view to an initial assessment of the maturity and adequacy of the safety options currently proposed.

STRESS CORROSION DAMAGE TO PIPES CONNECTED TO THE MAIN PRIMARY CIRCUIT OF EDF REACTORS: A COMPLEX PHENOMENON

At the end of 2021, a phenomenon of stress corrosion cracking (SCC) affecting the pipes connected to the primary circuit of several EDF nuclear reactors was observed, leading to the prolonged shutdown in 2022 of around a dozen of them. This is a fairly common type of corrosion in conventional industry but less common in nuclear power, and generally results, for corrosion-prone materials, from the combined action of mechanical stress and an aggressive environment. This damage generates one or more cracks, which then spread within the material concerned. *"In reactors, the main cooling circuits and connected circuits are made of stainless steel – alloys of iron, chromium and nickel. The basic corrosion mechanism observed is linked to thermally activated oxidation of the metal,"* explains Olivier Dubois, deputy director of nuclear safety expertise at IRSN. *"For a given mechanical load and chemical environment, the higher the temperature, the faster the cracks will spread."* Defects resulting from SCC in stainless steel piping are particularly difficult to detect by non-destructive testing (ultrasound or X-ray). *"Furthermore, this is a pernicious phenomenon, insofar as regular inspections of the pipes can only identify the defect once it has become fairly deep. Lastly, the speed at which the cracks spread cannot be characterized precisely for the moment",* Mr Dubois goes on to say.

In parallel with the actions implemented by EDF, in 2022 IRSN used its simulation tools to assess the potential consequences of the rupture of the pipes concerned to evaluate the concomitant safety issues and share its findings with EDF. As EDF continues its work replacing the sections concerned and IRSN analyzes the various aspects of EDF's files, the root causes of the damage remain uncertain: excessive mechanical stresses due to thermal stratification phenomena, welding anomalies, chemical effects in which oxygen present in the water could play a major role, or something else?

As part of its research in 2022, the Institute also continued its work, in collaboration with international partners such as the United States Nuclear Regulatory Commission (US NRC), on achieving a better understanding of the propagation of ultrasonic waves in stainless steels. The results obtained will enable IRSN to take a stance on the performance of non-destructive testing implemented today and testing methods currently under development.



PERIODIC REVIEW OF THE SAFETY OF THE UP2-800 PLANT (INB No. 117) IN LA HAGUE

As part of the expertise of this periodic review, in 2022 IRSN presented to the Permanent Group of Experts for Laboratories and Plants (GPU), working closely with the ASN, the conclusions of its assessment of the supplements relating to the NPH workshop, focusing on this workshop's behavioral studies in the event of natural hazards (earthquake, wind, etc.). The Institute underlined the extent of the reinforcement and deconstruction work that the operator has engaged to carry out, considered that the compensatory measures put in place by Orano as part of the periodic review of the UP2-800 plant had to be maintained until the work is completed, and stressed that this work should enable compliance with the safety requirements currently defined for this INB.



IRSN EXAMINES THE SAFETY OF THE DECOMMISSIONING OF FESSENHEIM

The decommissioning of a nuclear facility is a complex operation, raising questions about multiple issues relating to safety, radiation protection, and waste management. As part of its expertise missions, IRSN assesses, at the request of the ASN, the safety provisions proposed by operators in the file attached to the decommissioning decree request. In 2022, the Institute commissioned the assessment of the decommissioning file for the Fessenheim power plant (Haut-Rhin) whose two reactors were shut down in 2020. These two 900 MWe reactors will be the 2nd and 3rd PWR reactors to be decommissioned in France, following that of Chooz A (Ardennes).

The law of 2015 on Energy transition for green growth (TECV law) provides for the principle of immediate decommissioning to avoid foisting on future generations the burden of the related operations; it implies having timely access to the necessary provisions, reliable technical solutions, and industrial channels for radioactive waste management. In terms of safety, this principle has many advantages, such as rapid evacuation of the most radioactive substances, better knowledge of the state of the facility to be decommissioned, internal availability of human resources and skills, and fewer effects of aging. More generally, this approach reduces risks to the public and the environment at the earliest possible stage.

Spread over several years, the management of a decommissioning project begins by characterizing the initial condition of the facility concerned and precisely defining the target condition. From there, the actual reactor decommissioning is organized into four main stages: evacuation of materials and waste present, in particular in the reactor building; dismantling of the equipment present (reactor vessel, steam generators, primary and secondary circuits, etc.); clean-up of the premises (monitoring of their rehabilitation or complete deconstruction) and, finally, soil decontamination. At present, in France, several nuclear facilities – fuel cycle plants, laboratories, research reactors, etc. – are in the course of being decommissioned and dismantled. As such, they provide useful feedback on the safety of these operations, which require specific safety planning and analyses, paying particular attention to the risks of dispersion of radioactive materials due to internal factors such as fire or to co-activity, taking into account organizational and human factors.

In the case of the Fessenheim power plant, IRSN has already taken a stance on the removal operations for equipment no longer necessary for facility safety due to the fuel's removal. Operations prior to the start of the actual decommissioning (planned for 2025) – such as decontamination of the primary circuit or evacuation of the different parts of the old steam generators stored on site – are in progress, scheduled or already completed.

Alongside these operations, the Fessenheim power plant provides an opportunity for *in vivo* studies of the effects of aging phenomena, particularly on equipment or materials inaccessible during regular operations or whose controls are limited. For IRSN, samples of materials and components should therefore be planned, in order to conserve them for future research and development programs, before they are altered by the dismantling operations.

REASSESSMENT OF THE SEISMIC HAZARD FOR 1,300 MWE REACTORS

In 2022, the Institute examined the seismic movements defined by EDF for the reactors in the 1,300 MWe reactor series based on historical earthquakes. In its technical notice, the Institute considers the seismic hazard satisfactory for all sites, with the exception of Cattenom and Saint-Alban. Furthermore, it considers that the new method proposed by EDF for determining the magnitude/depth pairings of historical earthquakes presents several positive developments. Nevertheless, IRSN needs additional information to verify the validity of certain choices and assumptions used by EDF in the calibration and application phases of this method.

MAJOR ADVANCES IN IRSN'S EXPERTISE FOR THE COMMISSIONING OF THE FLAMANVILLE 3 EPR

In 2022, IRSN produced around twenty technical notices dealing with the prospective commissioning of the Flamanville 3 EPR. Several of them concern EDF's processing of anomalies affecting pipe welding. Overall, the corresponding information was considered acceptable by IRSN. Regarding the reactor systems that are important for safety, the expertise conducted on the pressurizer valves revealed, despite constructive modifications, a need for reinforced monitoring in operation. The assessment on "recirculation", i.e.: the possibility of cooling the core long-term following an accident, shows that this subject continues to require attention; demonstration tests are still underway. Finally, during the operation of the first EPRs commissioned worldwide, localized fluctuations in core power and fuel failures have been observed. To address this issue, EDF has provided for solutions which, according to IRSN, are acceptable in principle. In 2023, these assessments should be concluded, and the analysis of the reactor start-up tests continued.

ANALYSIS BY IRSN OF THE EDF FILE RELATING TO THE IMPACT OF ENERGY MIX SCENARIOS ON THE NUCLEAR FUEL CYCLE

At the request of the ASN, IRSN assesses the studies conducted periodically by EDF on overall fuel cycle consistency. In this context, the Institute published in 2022 a technical notice on the impact of energy mix scenarios on the nuclear fuel cycle. "While these scenarios apply first and foremost to nuclear power reactors, their impact extends to all facilities in the nuclear fuel cycle, which must be adapted to changes in reactor operation," says Igor Le Bars, IRSN's Director of Safety Expertise. "Therefore," adds Jean Lombard, responsible for fuel cycle operation monitoring at IRSN, "the Institute examined in particular the operating difficulties or constraints likely to impact facility capacities for processing spent fuel assemblies and manufacturing fuel assemblies based on mixed uranium and plutonium oxides (MOX), the management of MOX waste, transportation, and the overall functioning of the fuel cycle."

In its notice, IRSN issued recommendations relating, first of all, to the monitoring of ongoing projects to prevent saturation of plutonium storage capacity (related to production difficulties at the MELOX plant for the manufacture of MOX fuel assemblies) and fuel assembly storage capacity (related to the reduction in the processing capacity of spent fuel assemblies at the Orano Recycling site in La Hague). "The Institute also recommended the implementation of a system for regularly monitoring the fuel cycle operation to better prevent or deal with hazards that may occur at a facility in operation or in the process of being built," Mr. Le Bars goes on to say. "Finally, IRSN recommended an update to the long-term prospective analysis – carried out in 2020 – of the effects of multi-annual energy planning on fuel cycle consistency."

In addition to publishing its technical report, available on its website at the request of HCTISN, IRSN decided to produce an illustrated and commented version of its technical notice for the general public and stakeholders in civil society (local information commissions in particular), a document which is also available on its website.



IRSN REVIEWS EDF'S FEEDBACK ON THE BEHAVIOR OF FUEL IN REACTORS FOR THE PERIOD 2010-2019

IRSN presented to the permanent group of experts for reactors at the ASN its assessment of the feedback acquired by EDF in terms of both the manufacture and the operation of fuel assemblies and control rod clusters in its reactors for the 2010 - 2019 period. Over this period, the operator used, in the 58 pressurized water reactors (split into three standardized series of 900, 1,300 and 1,450 MWe) that currently make up its nuclear fleet, different types of fuel assemblies and clusters supplied by Framatome and Westinghouse. Over time, these products have undergone design and manufacturing changes driven by the desire to improve the safety, reliability and performance of fuel cycle operation. The evolution of these products has taken into account changes to safety standards, consistency of the fuel cycle – which currently includes recycling of spent fuel in France to manufacture mixed uranium-plutonium oxide (MOX) and enriched reprocessed uranium fuels – and supply security, as well as the lessons learned from their manufacture.

In its analysis of feedback over this period, IRSN has noted the efforts of EDF and its suppliers to improve the means of identifying and processing fuel failures (such as fuel rod cladding failure) and deploy new product designs. IRSN concluded in its notice that, although the feedback is generally satisfactory, EDF must monitor fuel behavior closely and draw more lessons from feedback acquired internationally; the operator has committed to doing so.

IRSN AND THE GERMAN AND CZECH TSOS SUBMIT A JOINT REPORT TO THE CLEARINGHOUSE

The European Nuclear Safety Clearinghouse – set up in 2010 for the benefit of the nuclear safety authorities and technical bodies of the EU Member States, as well as international organizations and the wider nuclear community – manages a centralized database of lessons learned from the operational experience of nuclear power plants in order to improve safety. For example, it enables countries with few nuclear reactors to benefit from the feedback and experiences in countries operating large fleets, such as France.

The Clearinghouse has several functions. These involve, in particular, collecting operational feedback data from a number of international and national sources; assessing key nuclear safety events and alerting the relevant national regulatory bodies; providing summary reports of events with similar characteristics or causes; conducting studies of precursor events at all relevant nuclear facilities; and disseminating information about corrective actions taken at certain facilities in response to lessons learned.

In 2022, a consortium of experts from the German TSO (GRS), French TSO (IRSN) and Czech TSO (SÚRO) issued new recommendations relating to the protection of nuclear power plants against the effects of external hazards of natural or human origin (excluding malicious acts) in a joint report entitled *TOER External Hazard-Related Events II*. Based on the analysis of significant events that occurred between 2010 and 2020, and which were recorded in national databases in France, Germany, and the Czech Republic, as well as in the International Reporting System for Operating Experience (IRS) database, this report provides recommendations to the nuclear safety authorities of Clearinghouse Member States in the interest of limiting consequences on facilities from phenomena such as earthquakes, lightning, heat waves, frost, explosions, etc.

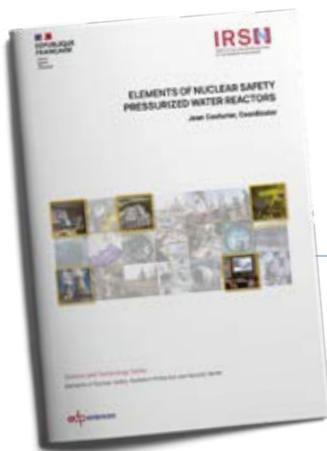


COVID-19: IRSN TOOK PART IN A FEEDBACK SEMINAR

Organized on June 1, 2022 by the Nuclear Energy Agency (OECD/NEA) with the contribution of IRSN, this forum was attended by a group of experts to reflect, based on feedback from three business areas (civil aviation, healthcare facilities, and the nuclear industry), on ways to strengthen the resilience of the nuclear sector. The objective was, in particular, to review the experiences of different organizations and identify best practices to better prepare for future crises.

THE PUBLICATION, ENTITLED *ELEMENTS OF NUCLEAR SAFETY – PRESSURIZED WATER REACTORS*, IS AVAILABLE IN ENGLISH

The English version of this reference work, published in 2020, encapsulates seven years of efforts to capitalize on nuclear safety knowledge and was supervised by Jean Couturier. This educational publication, which is unparalleled internationally, can be downloaded free of charge on the IRSN English website, in the *Science and Technical Collection*.



To download the book, click on the QR code



NEW EXPERTISE SERVICES IN EUROPE

IRSN was selected in 2022 as part of two European calls for tenders launched by the Dutch safety authority ANVS (*Autoriteit Nucleaire Veiligheid en Stralingsbescherming*) and Norwegian safety authority DSA (*Direktoratet for strålevern og atomtryggleik*) which were each seeking a partner or consortium able to perform TSO functions.

Concerning ANVS, IRSN has partnered with the Belgian TSO BelV and Bureau Veritas to respond to the three lots of the tender: assessments, inspections, and recommendations for future developments. The five-year contract is renewable up to a total term of 10 years.

For the second call for tenders, launched by DSA, IRSN partnered with BelV, the Australian safety authority (ARPANSA), and a Norwegian university (NMBU). The services will focus in particular on the future decommissioning of nuclear reactors and spent fuel disposal facilities.

These two contracts will strengthen the Institute's European positioning in terms of safety expertise and consolidate its privileged relationship with BelV.





RISK OF COASTAL FLOODING: IRSN CONTRIBUTES TO A NEW ESTIMATION METHODOLOGY

The coastal location of many nuclear facilities makes them vulnerable to the risk of coastal flooding, which means accurate estimates of extreme sea levels are of vital importance. As part of a Franco-Quebec research team combining the National Institute for Scientific Research (INRS) and Gustave Eiffel University, IRSN participated in the development of a methodology for improving integration of historical data, which is of interest to many nuclear sites around the world as well as to other types of coastal infrastructure such as ports or bridges.

SAFETY IN RADIOACTIVE WASTE MANAGEMENT: A BUSY YEAR FOR IRSN

IRSN experts were asked in 2022 to make various contributions to the safe management of radioactive materials and waste, both nationally and internationally. Whether to inform political choices in this area, to provide technical support for Nuclear Safety Authority decision-making, or to develop international agreements to meet present and future challenges, the Institute mobilized its expertise throughout the year, as evidenced by the following three actions.

Fulfilling its mission of providing support to the public authorities, in accordance with regulatory provisions, IRSN submitted to the Minister of Energy a proposal for a multi-actor, multi-criteria analysis methodology concerning possible management options for certain types of radioactive materials and waste, as part of the French national management plan (PNGMDR). The objective of this methodology guide is to facilitate public decision-making assistance by identifying the criteria selected by a variety of stakeholders in order to highlight the benefits and drawbacks of each waste management option, with regard to environmental and health, safety, socio-economic, and territorial issues. The guide will enable authorities to co-construct this type of analysis in an open and transparent manner, prior to making their decisions.

IRSN analyzed the dossiers relating to the safety review of the Manche Disposal Center (CSM), a LILW-SL (Low- and Intermediate-Level Short-Lived) waste disposal facility located within the town limits of La Hague. Presented to the permanent group of experts for waste at the ASN, the Institute's conclusions show that the safety level of the CSM, which received LILW-SL waste until 1994, is currently satisfactory and under control for the monitoring phase of several hundred years. However, the Institute points out that the solution envisaged by Andra to improve the longevity of the site's coverage leaves residual risks in the event of intrusion into the disposal area beyond this monitoring phase; therefore, the memory of these risks must be transmitted and the opportunity to remove certain waste assessed.

Finally, IRSN also contributed to the IAEA's activities by participating from June 27 to July 8, 2022 in the 7th meeting of the IAEA Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management in Vienna. At the request of the ASN, representing France at this Convention, the Institute analyzed some fifty reports from contracting countries. It also chaired a review group of the national programs of 11 countries that are signatories to the Convention and participated in presentations made at the review meeting.





NUCLEAR DEFENSE SAFETY, NUCLEAR SECURITY, NUCLEAR AND CHEMICAL NON-PROLIFERATION

IRSN provides support – through its Defense-Related Nuclear Safety, Nuclear Security and Nuclear & Chemical Non-Proliferation Division – to the authorities (namely the DSND [representing the office of nuclear safety for defense-related facilities and activities], and the HFDS [senior official for defense and security] of the Ministry of Energy Transition) responsible for defining and implementing defense and security policies, in particular the safety of nuclear facilities and civilian transport.

In this context, the Institute's experts are called on to fulfill a number of missions such as examining the safety files of defense-related nuclear facilities, analyzing safety and security studies relating to nuclear materials, facilities and transport, and providing support for inspections carried out under France's international commitments in the field of nuclear and chemical non-proliferation. The Institute also supports the authorities by contributing to the revision of regulatory texts governing nuclear security, and the non-proliferation of nuclear materials.

2022 saw the continuation of the review of safety files relating to the new generation of *Barracuda* nuclear attack submarines, and in particular the *Duguay-Trouin*, and assessments of the security studies carried out by the CEA for its main civil nuclear sites, as well as IRSN's participation in various national nuclear security exercises. Internationally, the Institute provided support for the UK Office for Nuclear Regulation in the assessment of the UK nuclear materials control system.

IRSN'S CONTRIBUTION TO THE DEVELOPMENT OF THE REGULATORY FRAMEWORK

As part of the support it provides to the authorities, IRSN participated in the review of regulatory texts in 2022 in various fields related to nuclear security and the non-proliferation of nuclear materials.

With regard, firstly, to the protection and control of nuclear materials, facilities and transport, the Institute has contributed, within the working parties set up by the Ministries for, respectively, Energy Transition and the Armed Forces, to the drafting of the implementing orders for Decree No. 2021-713. These orders include in particular the authorization procedure and demonstration of security, physical protection, physical monitoring and accounting of nuclear materials, nuclear security management and information system security. Transitional measures provide for the phased application of this legislation by 2027.

IRSN also participated, as technical support for the Euratom Technical Committee (CTE), in the negotiations to review the introduction of subsidiary arrangements to the French safeguards agreement, conducted with the European Commission and the International Atomic Energy Agency (IAEA). These could ultimately lead to changes in the list of facilities eligible for Agency inspections and to a review of the formats for transmitting information to the Agency.

As part of the implementation of the Euratom-Third Countries agreements, IRSN has analyzed, on behalf of the CTE, the updated "*Guidelines for the application of the Euratom-Third Countries agreements; 2022 revision*", a document intended to guide operators and the authorities of the Member States in the application of these agreements, in particular with regard to the actions required for transfers and inventories of nuclear items.

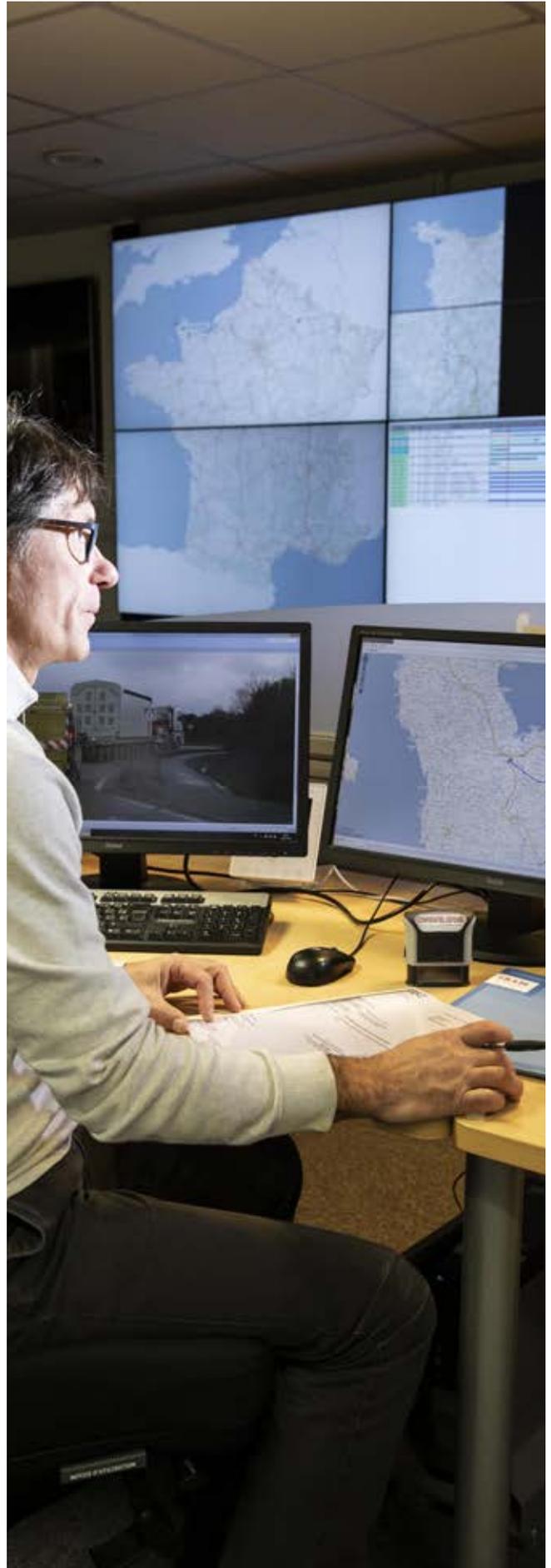


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TECHNICAL
OPINIONS AND
REPORTS TO
THE EURATOM
TECHNICAL
COMMITTEE (CTE)
AND HFDS OF THE
FRENCH MINISTRY
OF ENERGY
TRANSITION

EXPERTISE OF SAFETY DOSSIERS RELATING TO THE LOADING AND DIVERGENCE OF THE NUCLEAR CORE OF THE *DUGUAY-TROUIN* NUCLEAR ATTACK SUBMARINE

As part of the *Barracuda* program to renew the six nuclear attack submarines of the French Navy, and after the *Suffren* entered service in summer 2022, trials of the *Duguay-Trouin* continued with the loading and divergence of the reactor on 30 September 2022. As part of its technical support brief for the Defense Nuclear Facilities Safety Authority (ASND), IRSN examined the safety files relating to these stages. The Institute will continue its assessment work in 2023 during the *Duguay-Trouin* sea trials phase.





CONCLUSIONS OF THE IN-DEPTH TECHNICAL INVESTIGATIONS OF THE CEA FACILITIES IN TERMS OF SECURITY

IRSN was contacted by the Office of the senior official for defense and security (SHFDS) of the Ministry of Energy Transition to carry out an expertise of the security studies (protection and control of nuclear materials and associated activities to counter malicious acts and misappropriation) of the French Alternative Energies and Atomic Energy Commission (CEA) for its main nuclear sites. After finalizing in 2021 the assessment of studies concerning the CEA center in Fontenay-aux-Roses (Hauts-de-Seine) and transmitting its conclusions to the SHFDS, the Institute was entrusted by the SHFDS in 2022 with conducting a study assessment for the CEA sites in Saclay (Essonne), Marcoule (Gard) and Cadarache (Bouches-du-Rhône). For each of the sites, a notice and an assessment report were written up and sent to the SHFDS, most recently in September 2022.

During the assessment phase, IRSN discusses technical matters with the operator. This malicious acts study assessment requires in-depth knowledge of the configuration of the sites and their protective measures in order to assess their vulnerability to malicious acts.

SUPPORT FROM IRSN FOR THE UK OFFICE FOR NUCLEAR REGULATION FOR THE EVALUATION OF THE NUCLEAR MATERIALS CONTROL SYSTEM

Since its exit from the European Union in 2020, the United Kingdom has no longer been able to turn to the European Commission for the implementation of its nuclear safeguards obligations vis-à-vis the IAEA and the countries with which it has nuclear cooperation agreements. In this context, at the beginning of 2022, the competent British authority called for a "peer review" of the new organization of the British national nuclear safeguards system, with two representatives of the Euratom Technical Committee and one from IRSN. *"The Office for Nuclear Regulation (ONR) approached us to assess the safeguards system put in place by the competent UK authorities for the control of nuclear materials,"* says Romuald Bon Nguyen from the Non-Proliferation and Accounting Department. *"In order to carry out this peer review, we held discussions with ONR representatives and with manufacturers concerned by nuclear materials regulations, in particular during two missions conducted in the United Kingdom, one in May and the other in July. We also participated as observers in an ONR inspection, which gave us an overview of the methods in place."*

The report drawn up as a result of this assessment highlights the UK's good nuclear safeguard practices and highlights the maturity of the system in place with regard to its international obligations. Furthermore, the report proposes avenues of reflection for the ONR and, more broadly, for the competent UK authorities.

**WAR IN UKRAINE:
IRSN MOBILIZED TO SERVE
PUBLIC AUTHORITIES
AND CITIZENS**



"Faced with an unexpected situation in emergency planification, IRSN has found innovative responses that have enabled it to be effective, consistent, and to enhance its resilience. The strength of the Institute lies in its ability to adapt to challenges and meet them by relying on a formidable emergency response asset: the multidisciplinary nature of its teams. We possess knowledge of the nuclear facilities, environmental monitoring issues, radioactivity dispersion behavior, health risks, the international situation, communication, and more. Through the synergy of all our skills, amplified by this crisis, we are able to remain in a state of readiness for the duration with regard to the Ukraine situation, covering a broad field, while preserving the Emergency Response Center's responsiveness in its daily missions."



Jean-Christophe Niel,
Director General of IRSN

On February 24th, 2022, Russian troops invaded Ukraine on four fronts and seized control of the Chernobyl site, where 20,000 spent fuel assemblies are stored. The very next day, IRSN mobilized its emergency response organization, activating its Emergency Response Center (ERC) in Fontenay-aux-Roses (Hauts-de-Seine) to carry out its technical and scientific missions to support national public authorities and international bodies. These missions involve daily monitoring of radiation levels on Ukrainian and European territories, assessing the safety of Ukrainian nuclear facilities; anticipating possible accident situations and their potential consequences for populations and the environment in Ukraine, Europe and France. IRSN was also mobilized to respond to media and civil society inquiries and produced information notes and educational materials on the situation of nuclear facilities in Ukraine in order to contribute to an understanding of the risks.

But the war continued to drag on. At various times, Ukrainian nuclear facilities were hit by artillery shellings, causing concerns as no other nuclear country had previously experienced an armed conflict of this scale^[1]. Never before had nuclear power plants been used as military targets, knowing that they are not designed to withstand warfare. And the risk of a severe radiological accident had never before posed such a serious threat to Europe.

Faced with this unprecedented, evolving and often disquieting situation, IRSN emergency response teams, supported by various expert within the Institute, remain mobilized. For 10 months, they adapted their organization, mobilization and involvement as the events, solicitations and issues unfolded. Managing this crisis, different from that of Fukushima-Daiichi in Japan in 2011, led the Institute to adjust the working methods of its Emergency Response Center. Internally, it involved employees and fostered collaborative work and synergy among multidisciplinary teams. Externally, it highlighted the importance of IRSN's role as a technical expert able to provide support for the public authorities in the ecosystem of international crisis management.

As of December 31, 2022, none of the attacks directed at Ukrainian nuclear facilities or power infrastructure had caused damage to critical zones or generated any episodes of radioactive release. No abnormal increase in radioactivity had been detected by the monitoring networks, either in Ukraine or in neighboring countries. Nevertheless, major risks still persist. The Institute therefore remains mobilized on active standby. IRSN will continue to support the nuclear safety initiatives undertaken by European and international safety organizations, foremost among which is the IAEA and its Director General Rafael Grossi, to preserve safety.



UKRAINE, A COUNTRY WITH EXTENSIVE NUCLEAR FACILITIES

Ukraine is the world's seventh-largest producer of nuclear power and, in an area slightly larger than France, had a total of fifteen VVER pressurized water reactors of Russian design in operation over four production sites on February 24, 2022. In addition to these nuclear power plants, there are:

- Two research reactors;
- Six storage and disposal sites for radioactive sources and waste;
- Four RBMK reactors at the Chernobyl site, shut down since 2000: three being dismantled, one under the sarcophagus (the damaged reactor);
- Various facilities required to manage the Chernobyl accident site, including a storage pool for 20,000 spent fuel assemblies and a dry storage facility for 2,000 spent fuel assemblies.

ROBUST AND RESILIENT POWER PLANTS

Designed differently than Chernobyl, the reactors of the four Ukrainian nuclear power plants meet international nuclear safety standards. Each one was equipped from the outset with:

- A pre-stressed concrete containment (except for two Rivne^[2] reactors) which also houses the spent fuel pool;
- Three independent standby emergency power generators with seven days' fuel autonomy. A single generator combined with a set of safety systems is enough to cool the core of a reactor and the spent fuel pool.

In addition, Ukraine reinforced the safety of its power plants following stress tests in Europe carried out after the Fukushima-Daiichi power plant accident. Each power plant has mobile back-up equipment, enabling it to deal with the total failure of internal and external power supply (mobile water injection heat pumps, mobile generators, with three days' fuel autonomy).

The country has also launched the rollout of a filtered containment venting system on its reactors, which limits, in the event of a severe accident, the release of volatile radioactive elements. Other provisions, such as hydrogen recombiners, have been installed to limit the risk of loss of containment.



[1] Slovenia's war of independence had led, as a precaution, to the temporary shutdown of the Krško power plant in 1991.

[2] The Rivne power plant comprises two 440 MWe reactors, older than the other VVER reactors located in Ukraine.

A LONG TRADITION OF COOPERATION BETWEEN IRSN AND UKRAINE

The safety of Ukrainian nuclear power plants, all operated by the National Nuclear Power Generation Company of Ukraine Energoatom, is controlled by the SNRIU (State Nuclear Regulatory Inspectorate of Ukraine).

Following the Chornobyl accident, IRSN forged cooperative relationships with SNRIU, within the framework of the European ICSN (Instrument for Nuclear Safety Cooperation) program, through assistance and skills transfer contracts in the field of nuclear safety and radiation protection. These cooperative relationships – particularly in the context of post-Fukushima stress tests and as part of the European FASNET project, led by IRSN, to prepare for and respond rapidly to nuclear emergencies at the international level – have enabled the Institute to acquire knowledge and data on east-European VVER reactors. Furthermore, the Institute bolstered its workforce with experts of Ukrainian nationality.

Since 2010, SSTC, the SNRIU technical safety organization (TSO), has been an associate member of ETSON, the European TSO network, which was created at the initiative of IRSN and Belgium and German TSO to contribute to consolidating European nuclear safety.

IN BRIEF

REACTOR SAFETY IN AN ACCIDENT SITUATION

Three conditions are essential to maintaining the safety of an operated or shut-down reactor:

- Water supply for the cooling circuits;
- Power supply to operate safety equipment and to run the water injection pumps in the reactor core or spent fuel pool and the cooling circuit pumps;
- Trained operating and maintenance personnel, who are operational and free to make their own decisions and act on them.

10 MONTHS OF ATTACKS ON UKRAINIAN NUCLEAR FACILITIES

PHASE 1 (FEBRUARY - MARCH)

DIVERSE ATTACKS

- **February 25, 2022:** Intrusion into the Chornobyl exclusion zone. Takeover of the site, occupied for 35 days. The media report on increased levels of radioactivity in the exclusion zone.
- **Night of February 26 to 27:** Attack on a waste disposal site in Kyiv, no radioactive release.
- **Night of March 3 to 4:** Attack and takeover of the Zaporizhzhya power plant, the largest in Europe.
- **March 6 and 11:** Shelling of the Kharkiv Institute of Physics Research Center.
- **March 9:** Loss of external power supply to all Chornobyl power plant facilities.
- **March 11–21:** Forest fires in parts of the Chornobyl exclusion zone generate an increase in measured radiation levels.

PHASE 2 (APRIL - JULY)

THE CONFLICT IN DEADLOCK

April 26: Arrival of IAEA mission at the Chornobyl site after the withdrawal of Russian troops.

PHASE 3 (AUGUST - MID-OCTOBER)

REPEATED OFFENSIVES NEAR AND AGAINST NUCLEAR POWER PLANTS

- **August to November:** More than twelve successive attacks (shelling) on the Zaporizhzhya site, generating major concerns about the possible consequences.
- **End of August:** Arrival of a permanent delegation of IAEA inspectors in Zaporizhzhya.
- **September 11:** Total shutdown of the last reactor still in operation at the Zaporizhzhya power plant.

PHASE 4 (MID-OCTOBER - DECEMBER)

A STRATEGY OF SHELLING ENERGY, ELECTRICITY AND WATER PRODUCTION AND DISTRIBUTION INFRASTRUCTURE

- **November 15:** Loss of one external power line at the Rivne plant. Shutdown of a reactor. Power reduction in the other three reactors. Shutdown of the two reactors at the Khmelnytskyi power plant.
- **November 23:** Loss of the national power grid. Automatic shutdown of all units at the nuclear power plants on the Rivne, Khmelnytskyi, South Ukraine and Zaporizhzhya sites.



IRSN'S INVOLVEMENT IN MANAGING THE UKRAINE CRISIS

PROVIDING SCIENTIFIC ADVICE AND OPERATIONAL ASSISTANCE TO PUBLIC AUTHORITIES

answering questions and direct requests from several ministries:

Health, Europe and Foreign Affairs, Armed Forces, Labor, Ecological Transition, etc.

MOBILIZING

02.25 TO 04.08: SETTING-UP THE EMERGENCY RESPONSE CENTER (ERC), DAILY MEETINGS

Director General, Crisis Director, Head of Emergency Assessment, "Facilities Evaluation" unit, "Radiological Consequences" unit, "Health" unit, "International" unit, "Communication" unit, "Logistical Support" unit + Ukraine pool and Operating Office of the Emergency Response Center

INVOLVING IN-HOUSE EXPERTISE ON A LARGE SCALE

Request for nine IRSN expert assessment services

ADAPTING TO A LONG-TERM CRISIS

08.22 TO 12.31: ACTIVE STANDBY

- Weekly meetings and monitoring bulletins
- Safety monitoring
- Environmental monitoring (daily monitoring)
- International monitoring
- Social network and media monitoring

CONTINUOUSLY INFORMING IN AN OPEN AND INSTRUCTIVE MANNER

PUBLICATION AND DISSEMINATION OF THE RESULTS OF EXPERT ASSESSMENTS IN THE FORM OF TECHNICAL BRIEFING NOTES, PRESS RELEASES, EDUCATIONAL MATERIALS TAILORED FOR THE GENERAL PUBLIC, INTERNAL BRIEFING NOTES:

- Three briefing notes on the "Situation of nuclear facilities in Ukraine"
- One educational notice: "Taking stable iodine tablets in emergency situations"
- Two briefing notes on the "Situation at the Chernobyl site"
- Four briefing notes on the "Situation at the Zaporizhzhya power plant"
- One briefing note entitled "Impact of the deterioration of the Ukrainian national power grid on nuclear power plants"
- Internal webinars
- Internal videos

Media: www.irsn.fr, social networks, REPERES external magazine, the IRSN newsletter, MyIRSN intranet, in-house magazine

RESPONSE TO A HIGH INFLUX OF REQUESTS:

- Media
- NGOs (Doctors Without Borders, etc.)
- Associations (CLI, ANCCLI, CRIIRAD, Greenpeace)
- Companies (France TV)
- HCTISN (High committee for transparency of information on nuclear safety)
- General public
- IRSN employees
- Parliamentarians, Elected Officials

ASSESSING THE POTENTIAL RADIOLOGICAL RISKS AND CONSEQUENCES

BUILDING A FORMAL AND INFORMAL NETWORK OF INTERNATIONAL CONTACTS

to escalate and aggregate reliable assessment data (Ukrainian employees, IAEA/USIE, SNRIU, Energoatom, SSTC (Ukrainian TSO), embassies, IAEA/IEC, NNSA, NARAC)

PRODUCTION OF "ATYPICAL" ASSESSMENTS FOR A BETTER ANTICIPATION

- Safety assessment of Ukrainian power plants
- Catalog of standard accident sheets for each family of Ukrainian nuclear facilities
- Worse-case scenario of radiological releases and consequences
- Risk studies

ANTICIPATING A POST-ACCIDENT SITUATION

Assessment of the consequences of a serious accident in Ukraine (possible restrictions on food marketing and consumption)





ANTICIPATING

The European theater of the crisis in Ukraine and the kinetics of events have challenged IRSN with unprecedented situations. To increase its responsiveness and enable the Government to anticipate the protective measures to be taken in France in the event of a severe radiological accident in Ukraine, the Institute has taken the initiative to broaden the scope of the assessments it usually carries out in emergency situations. It has worked in real-time on scenarios to anticipate serious events across Ukraine, adapting its tools and methods, and mobilizing targeted competences.

A STANDARD EMERGENCY RESPONSE ORGANIZATION TO START WITH

As soon as the Emergency Response Center (ERC) was activated, at midday on February 25, the IRSN emergency response organization's technical units were set up and running at the crisis director's request. Media demand for information intensified. The supervisory authorities requested an analysis of the situation in Ukraine and advice on protective actions to be considered. The Institute's teams were immediately set to work in the various units, including "Facilities Evaluation", "Radiological Consequences", "Health", "Communication", "International" and "Logistical Support". Within the first few hours, they conducted an analysis of the events, making it possible to produce and disseminate a preliminary briefing note on the "Situation of nuclear facilities in Ukraine".

During the first six weeks of the conflict, marked by a constantly changing and particularly unsettling situation, the ERC remained mobilized, most frequently during working hours. Gradually, a "Ukraine pool" of around thirty team members was formed to manage the crisis on an ongoing basis. It receives assistance when needed from specialized support units. Every morning, and as required, the crisis manager organizes a situational briefing, and decides what assessment work needs to be launched, and which methods and resources mobilized. He serves as the contact person for the public authorities.



A WIDE RANGE OF FRONTS, UNPRECEDENTED ISSUES

From the end of February to mid-March, the "Ukraine pool" was called upon to focus its assessments on highly mobile fronts: the Chernobyl site located less than 150 km from Kyiv, the capital of Ukraine, to the north; Zaporizhzhya, Europe's largest power plant, to the south-east; a waste disposal site near Kyiv; an experimental reactor in Kharkiv, to the north-east; then Chernobyl once again... The crisis team must adapt to the diverse types of nuclear facilities across the vast territory of Ukraine and the many radiological issues associated with them.

Rapidly, specific problems emerged which the teams had not encountered while managing the previous international nuclear crisis, that of the Fukushima-Daiichi power plant in 2011:

- **How can objective event information be collected** when the military conflict in Ukraine is accompanied by an "information warfare" that requires the deciphering of not only technical but also political and strategic situations?
- **How can reliable technical information be reported and centralized** to guarantee the quality of IRSN's assessments on the radiological consequences of attacks on Ukrainian power plants? IRSN is not in direct contact with Ukrainian operators, as they are with EDF in France; in Chernobyl and Zaporizhzhya, Ukrainian operatives work under the constraints of the Russian army.
- **How is it possible to characterize** spent fuel storage sites and research reactors on which IRSN has no data? It is difficult to accurately calculate potential radioactive releases when parameters are missing.
- **IRSN has more knowledge at its disposal concerning the four Ukrainian VVER power plants** because their technology is close to that of French power plants; the results of their European post-Fukushima stress tests provide useful information. Nevertheless, many questions remain: have maintenance operations been carried out? What is the status of the safety provisions? What is the condition of the emergency power generators, and what is their reliability over time? How badly have working conditions deteriorated for the Ukrainian personnel working under constraint?

This anticipatory questioning is bound to continue throughout the crisis. Over the course of events, new topics of investigation have emerged, such as the ability of the power stations and their backup systems to get through the winter, or the risks linked to the destruction of the Dnieper dams upstream and downstream of the facilities.



LOSS OF ELECTRICAL SOURCES: A SENSITIVE SUBJECT QUICKLY SPOTLIGHTED

"As early as February 25, we diagnosed a critical threat in our safety analysis: the shelling of the Ukrainian electric grid could lead to the loss of power to nuclear facility safety systems. Very quickly, IRSN decided to develop expertise on this complex topic. For months, we collected and consolidated information on the Ukrainian power generation and distribution grid and retrieved or established power plant connection diagrams. To do this, we mobilized power distribution specialists and had discussions with SNRIU and the IAEA, who had dispatched a mission on site. This work helped us better assess the situation and risks for each episode of power line loss. We even anticipated a widespread grid incident that would lead to the automatic shutdown of all plants. This is an issue that has remained a constant concern throughout the crisis. However, it should be emphasized that, over the course of the year, the Ukrainian energy companies have always been able to repair damage to the power grid to maintain the safety of the facilities."



Emmanuel Raimond,
Leader of the "Facilities Evaluation"
unit, Head of the Reactor
Emergency Operating Department
and Probabilistic Safety Studies



360° SUPPORT FOR THE PUBLIC AUTHORITIES

"This unprecedented context of an international crisis has confirmed IRSN's pivotal role in supporting national public authorities and international bodies. This war, which erupted at the very threshold of Europe and posed serious radiological threats on the continent, has led those responsible for handling crises at the highest levels of Government to look beyond the national frame of reference. The French Ministries of Ecological Transition, Health, Foreign Affairs, the Armed Forces, and Labor, and the State operators approached us directly, as a public expert on nuclear and radiological risks, for expert assessments and operational support with increasingly extended scope.

Internationally, we have had technical discussions with the IAEA, which has played a central role in disseminating the information it has centralized to the UN Member States as well as in managing this crisis, highlighting repeatedly the challenges this represents for nuclear safety. We have also had direct contact with SNRIU and shared assessment intelligence with our counterparts in the USA, Canada, Norway, Finland, and Germany.

Lastly, the Ukraine crisis has given rise to a network of crisis actors within ministries and international bodies. It has federated a new national community which has further extended internationally. As is often the case, an emergency situation has been an accelerator of organizational development."



Louis-Michel Guillaume,
Deputy Director General
of the Defense, Security
and Non-Proliferation Division



PRODUCING ATYPICAL ANTICIPATION ASSESSMENTS IN EMERGENCY SITUATIONS

As attacks on Ukrainian nuclear facilities continued, so did the questions raise in the media and referrals issued by the State. In response, IRSN experts have produced numerous calculations of possible consequences for populations and the environment. These assessments have been part of a process of preparing for and anticipating a radiological event. They have resulted in the drafting of technical briefing notes distributed to the public authorities and the media, before being laid out for public.

In the space of a few days, with the support of other IRSN departments, the "Ukraine pool" produced the following:

- A catalog of Standard Accident Sheets for each family of Ukrainian nuclear facilities: the 1,000 MWe and 440 MWe VVER operated reactors, research reactors, waste disposal sites, and spent fuel pools. The "Facilities Evaluation" unit identified the scenarios that could occur at the different facilities and the atmospheric releases into the environment associated with these scenarios. Then, the "Radiological Consequences" unit assessed the consequences for populations and the environment under different meteorological conditions. These sheets provide an order of magnitude for each typology of accidental release.
- Assessments for obtaining an order of magnitude of iodine releases for different accident scenarios at the Ukrainian power plants and for determining whether dose levels justifying the administration of stable iodine could be exceeded on French territory. This work has provided operational responses for the public authorities.
- In November, IRSN extended its studies on the start of the post-accident component in order to assess any actions to limit the consumption and marketing of certain foodstuffs that may prove necessary to comply with regulations in force and taking into account the impact of contamination on territories across Europe.



EVERYONE MOBILIZED, EVERYONE INVOLVED IN A CROSS-FUNCTIONAL CHALLENGE

"To produce our studies on Ukraine, we called on experts from two specialized services from IRSN's nuclear safety division: from Fontenay-aux-Roses and Cadarache where they were based, experts from the Neutron Physics Department for Criticality Risks (SNC) and from the Major Accidents Department (SAM) took up the subject. Using more sophisticated calculation resources than those of the ERC – which relies on simplified tools to enhance its reactivity – they have developed data sets representative of Ukrainian power plants, enabling us to perform radioactive release calculations using complex models that will be extremely useful in the event of actual releases in Ukraine. Throughout the crisis, the ERC has relied on internal expertise from many departments: for assessment of safety against malicious acts, nuclear safety studies, the safety of transport and fuel cycle facilities, the power grid, the safety of nuclear research facilities, atmospheric dispersion and the radiological consequences, severe accidents, healthcare and the environment, VVER experts, the IT department, purchasing, etc. This peripheral network has brought a great deal of added value, shedding light on certain subjects, and allowing progress to be made on others. The ERC has helped the Institute to innovate and develop new skills. It has stimulated collaborative work and team spirit. Mobilizing skills outside the "hard core" of the ERC crisis organization is an example of our target mode of organization. This unprecedented experience strengthens our conviction that crisis management is a cross-functional subject. Not only does it mobilize many multidisciplinary skills, it also involves a broad spectrum of the Institute's employees, who take an interest in what their company produces in this crisis so that they too can provide objective insight into stressful events."



Philippe Dubiau,
Executive Director for Emergency Preparedness and Response



MONITORING

Monitoring is at the heart of IRSN's emergency response expertise. It is based on a 24/7 operational warning system that guarantees the rapid acquisition of data in order to assess the risks as quickly as possible and protect the health of populations. To remain effective and reactive to numerous and diverse events occurring outside French borders, in a context where it has been difficult to recover reliable information, IRSN has extended its reach beyond its standard frame of reference. The Institute has adapted its monitoring organization and broadened the usual scope of its monitoring systems by deploying them in four areas: media, international, safety, and Europe-wide environmental monitoring.

ORGANIZED MONITORING SYSTEMS

Faced, on the one hand, with a lack of readily available technical data on the design of nuclear facilities in Ukraine and, on the other, with the difficulty of accessing reliable event-based information on the shelling that have occurred, the need to implement four monitoring systems became quickly apparent. During the six weeks of ERC activation, these organized watches produce daily – sometimes twice or three-times daily – situation reports, making it possible to review and decide on actions at the morning crisis meeting. They also feed into the regular flow of information that IRSN passes on to the public authorities.

This monitoring, which was scaled down on April 8, resumed at a more sustained pace on 22 August, when repeated strikes against the Zaporizhzhya power plant led IRSN to reactivate its crisis organization in the form of "active standby", punctuated by meetings and situation reports, which were no longer daily but weekly.

MEDIA WATCH

In order to be able to detect weak signals and to inform the ERC's technical teams in real time of events taking place in Ukraine, the "Communication" unit activated a media watch in France and abroad starting from February 25. Building on the Communication Department's tools, this watch is based on:

- Monitoring of all social networks, via hashtag-keywords (themes, nuclear sites that could be attacked, etc.) programmed on search engines. This monitoring includes Telegram – an alternative to WhatsApp –, which is hugely popular in Ukraine and has been used by the Ukrainian authorities to disseminate information since they were deprived of other means of communication.
- A watch of all conventional media (agencies, radios, TV, print media) to produce a daily IRSN "Ukraine special" press overview summarizing around 100 press clippings.



CROSS-REFERENCING AND VERIFICATION: A CONSTANT CONCERN

"The information war waged between Ukraine and Russia since day one is an extremely complex component of this war. It puts our ability to analyze, cross-check and verify information to the test. Beside the facts, and sometimes even before the facts, there are comments, influencing and fake news across the social networks. It is very difficult to distinguish information from disinformation. The communicators spend a lot of time sorting through and analyzing the content and information in order to qualify them before passing them on to the technical experts of the ERC to contribute to the analyses."



Marie Riet-Hucheloup,
Communication Director

INTERNATIONAL WATCH

At the same time, international monitoring has been set up. The "International" unit teams collect the information published by IRSN's historical international partners, from their respective websites: the crisis centers for technical support (TSO) and safety authorities in European countries as well as international organizations such as NNSA (National Nuclear Security Administration) and NARAC (National Atmospheric Release Advisory Center). They also cull the key elements of diplomatic news in relation to Ukraine and Russia. The teams publish a monitoring bulletin covering recurring themes that provide insight into the position of the various States and international agencies: how these are reacting, what preparations they are making, how they organize themselves, why they have decided to break off relations with Russia, etc.

SAFETY WATCH

As for the "Facilities Evaluation" unit experts, they have been collecting information on safety, first at the Chernobyl site, then at the Zaporizhzhya power plant, then at all the other facilities located across Ukraine. The challenge is to rapidly calculate the orders of magnitude of potential radioactive releases and the radiological consequences of possible accident situations. Knowledge about each reactor must be consolidated in order to anticipate accidental scenarios and provide an opinion on the seriousness of a situation very promptly, when one occurs.

With the support of Ukrainian colleagues who speak the language and are familiar with facility designs, the teams enter into direct contact with SNRIU and other local actors. The teams seek first-hand information to ensure that they correctly interpret the information provided by Energoatom about the situation. They also discuss situations and release calculations with their contacts from foreign safety organizations: GRS and BfS in Germany, STUK in Finland, SSM in Sweden, DOE in the USA. They have technical discussions with the IAEA Incident and Emergency Center (IEC).

THE ENVIRONMENTAL MONITORING SYSTEM IN UKRAINE AND NEIGHBORING COUNTRIES: A KEY TO IRSN'S VALUE CREATION DURING THE CRISIS

The monitoring system implemented by IRSN crossmatches and aggregates data from 1,100 sensors belonging to different monitoring networks:

In Ukraine:

- Data from the Teleray radiation station of the French Embassy in Kyiv and the IRSN station installed in Lviv when the Embassy was relocated;
- Data from the Ukrainian national network via the European EURDEP platform;
- Data from Ukrainian nuclear operators and the Ecocentre (Ukrainian Public Agency for the Management of the Chernobyl Exclusion Zone) via the IAEA web-based tool, IRMIS;
- Data from accessible web-based aggregation sites such as SaveEcoBot (aggregation of data from the Ecocentre, Ukrainian nuclear operators, and the Ukrainian HydroMet network).

In neighboring European countries:

- Data from national monitoring networks via the European EURDEP platform.

This system automatically provides real-time, clear visualization of the dose rate evolution over a wide area.

In France, permanent nationwide radiological monitoring is carried out by:

- The Teleray network operated by IRSN (440 radiation monitoring stations in metropolitan France and overseas territories that transmit an ambient dose rate measurement every 10 minutes);
- The IRSN OPERA-Air network (50 air sampling stations in metropolitan France);
- Operator monitoring networks (EDF, CEA, ORANO La Hague): 550 radiation monitoring stations.



ENVIRONMENTAL MONITORING EXPANDED TO EUROPE

"The taking of the Chernobyl site and the rise, measured on certain radiation monitors and reported by press agencies, in the level of radioactivity at the time of the Russian offensive, raised the question of environmental monitoring in Ukraine from day 1 of the war. How can you get to grips with the radiological situation in a distant country in order to put in place an expert assessment? On February 24, IRSN could rely only on one single, and vulnerable, tool which was exposed to the shelling: the equivalent dose rate radiation stations deployed by the monitoring networks of various countries, such as the French Teleray network radiation monitor installed on the French Embassy in Kyiv.

The solution was to organize remote monitoring. Very quickly, we put in place a system allowing us to analyze the radiological situation in Ukraine on a daily basis and inform the public authorities. This system collects radiation stations data from the various Ukrainian monitoring networks, in particular the data automatically transmitted to the European EURDEP network, and that of the IRMIS platform of the IAEA. Our monitoring has been expanded to include all neighboring countries of Ukraine, with a dual objective of backup and warning: detecting a radiological event that Ukrainian radiation monitors, inoperative due to shelling or power outages, for example, would be unable to detect; and being able, if necessary, to inform the French Ministry of Foreign Affairs about protection measures for French nationals present in Eastern Europe. This monitoring provides a snapshot of the radiological situation in Ukraine. We also talk about the data with our counterparts, who pass on the intelligence to their own national authorities. Second, with the help of IRSN's environmental data specialists, we have optimized the efficiency of this monitoring, which aggregates a huge amount of information, with some radiation stations transmitting a measurement every 10 minutes. This included setting up a dedicated database and easy-to-use interoperable interfaces for crisis teams and radiological remote monitoring teams who are on call around the clock. This automated system enables us to perform a rapid and precise analysis and interpretation of any abnormal increase in radioactivity levels, which are not necessarily linked to an incident at a nuclear facility. Such a spike may be due to natural events (storms, rain, drought), or a failure of the radiation stations."



Maxime Morin,

Leader of radiological monitoring in Ukraine, in neighboring countries and in France, and Head of the Environmental Metrology Analysis Department



IN TIMES OF WAR, TRUTH IS GAUGED BY ENVIRONMENTAL MONITORING STATIONS RESULTS

"In a country at war, where the battle of communication requires a highly critical approach to understanding the information disseminated by the belligerents about the nature of the damage, the only way to know whether a nuclear facility has released radioactivity into the environment is to take measurements around the facility under attack. The monitoring of radioactivity in Ukraine has made it possible to objectively gauge the safety assessments of the "Facilities Evaluation" unit, which had very little information to work with at the start of the conflict. This monitoring indicated whether the firing and shelling might have hit a safety-critical area. Thanks to the professionalism and training of the environmental monitoring teams, IRSN is able to accurately interpret any variation in radioactivity levels and indicate whether this can be explained by weather conditions, the failure of a radiation monitoring station, or some other cause."



Éric Cogez,
Head of Crisis Expertise,
Head of the Radiological
Intervention and Environmental
Monitoring Department

MONITORING WITH AN OPERATIONAL EMPHASIS

These four "watch units" set up by IRSN are not only used to provide a daily or weekly snapshot of developments in the situation. They also constitute four action levers:

- They help the Crisis Director decide on work to be launched or initiatives to be taken to solve problems or anticipate solutions to emerging issues.
- They provide the "Facilities Evaluation" and "Radiological Consequences" units with a sum of verified knowledge and data, to consolidate and reinforce the reliability of the assessments they carry out.

A SUCCESSION OF SAFETY AND RADIATION PROTECTION ASSESSMENTS IN DIFFERENT LOCATIONS

After each event on a nuclear site, IRSN's diagnostics shed light on the situation. These diagnostics provide objective scientific insight into the nature of the actual damage and associated risks in a context where information is difficult to obtain and validate. The expert assessments provide input for technical briefing notes written up for the public authorities and, when appropriate, for elected representatives and associations, and published on the IRSN website.

Events	IRSN expert assessments
Increase in the radioactivity level measured by certain radiation stations in the Chornobyl exclusion zone	After exchanges with its European partners and the IAEA, the "Radiological Consequences" unit tends to favor the explanation of a technical malfunction of the radiation stations, without excluding the hypothesis of Russian tanks disturbing radioactive dust by driving through the area.
Power supply cut off for all Chornobyl power plant facilities. Evoking the risk of a "new Chornobyl"	The "Facilities Evaluation" unit dismissed a dewatering risk of the assemblies in the spent fuel pool, based on post-Fukushima studies and its own calculations. It assesses the site's other issues: risks associated with direct shelling of the sarcophagus and of the spent fuel pools.
The first shelling of the Zaporizhzhya power station indicating damage to the containment	The "Radiological Consequences" unit confirmed the absence of releases. The "Facilities Evaluation" unit, based on a study of the power plant design and its power supply resources, assessed the robustness of the power plant and confirmed approximately 10 days of autonomy in the event of total loss of external power supply, provided that the site teams remain operational.
Forest fires in the Chornobyl exclusion zone leading to an increase in measured radioactivity	The "Radiological Consequences" unit combined the data from its monitoring in Ukraine with the measurements of aerosol filters from other European countries and its OPERA-Air network, which detects minute traces of radioactivity in the air. No abnormal increase in radioactivity was observed.
Month-long shelling at the Zaporizhzhya power plant, which give cause for concern	The "Facilities Evaluation" unit approached the Energoatom operator to assess the extensive damage. The "Radiological Consequences" unit measured no increase in radioactivity. IRSN alerted the authorities to the degraded situation of the power plant and detailed the site's vulnerabilities: areas identified as safety-critical with regard to radiological risks and the main safety issues.
Loss of power supply to the South-Ukraine power plant, then systematic shelling of the Ukrainian power grid leading to the automatic shutdown of all reactors at the four power plants	The "Facilities Evaluation" unit assessed the means and time required to gradually rebuild the power grid in order to restart the reactors. IRSN stressed the need to reconstruct the national power grid to guarantee a sustainable power supply for nuclear site safety systems.
Arrival of winter	The "Facilities Evaluation" unit carried out a preventive assessment of the capacity of Ukrainian power plants (in particular Zaporizhzhya) to manage the winter season. The unit validated with the operator the implementation of thermal protection for the emergency power generators.

10

TECHNICAL BRIEFING NOTES FOR THE PUBLIC AUTHORITIES

- Three briefing notes on "The situation of nuclear facilities in Ukraine"
- Two briefing notes on "The situation at the Chornobyl site"
- Four briefing notes on "The situation at the Zaporizhzhya power plant"
- One briefing note on "The impact of deterioration of the Ukrainian national power grid on the nuclear power plants"

+ 1
EDUCATIONAL NOTICE ON "THE TAKING OF STABLE IODINE TABLETS IN AN EMERGENCY SITUATION"



ADAPTING

IRSN demonstrated agility throughout the 10 months of war in 2022. It has undergone a transformation, by reaching beyond its traditional emergency response “procedures”, poorly suited to the situation in Ukraine. Innovation has enabled it to adapt its organization, mobilization, involvement, methods, and tools to address the specific features of the Ukraine crisis: highly fluctuating events and demands, intense periods, no accidents but a permanent risk, continuous tension, and a long crisis with no end in sight.

FLEXIBLE EMERGENCY RESPONSE CENTER ORGANIZATION

During the ERC’s set-up period, the crisis organization went beyond its traditional frame of reference, while remaining true to its main principles. To adapt to highly fluctuating events and demands, the crisis units and mobilized workforce vary from day to day, and often over the course of the same day, depending on what has to be dealt with. They work in hybrid mode: some on site, others remotely.

The work is carried out mainly during working hours by the “Ukraine pool” team representing the key functions. These experts, mobilized from the start of the crisis, have access to the history of all the actions carried out by the ERC. At night and on weekends, the on-call team members ensure monitoring activities, ready to alert the Emergency Response Director, carry out initial assessments, and, in the case of a major event, call on the “Ukraine pool” team members to assist.

REGULAR OPERATIONAL TRAINING FOR ON-CALL TEAM MEMBERS

In order to build on-call team members’ awareness of the real risks to Ukrainian nuclear facilities, training sessions are regularly organized. These operational exercises are based on the theoretical anticipation carried out by their colleagues in the “Ukraine pool”: the Standard Accident Sheets for each family of Ukrainian nuclear facilities and the pre-calculated worst-case scenario. Based on the values of an accident scenario and the day’s meteorological data from *Météo France*, the on-call team members practice making calculations across the entire operational chain: assessment of the accident situation, calculation of the release, estimation of the spread of the plume over Europe, identification of zones that would require protection measures for the populations, drafting of the ERC external message of information for the public authorities. These training sessions, implemented before summer 2022, were reactivated in mid-November on a weekly basis. They promote knowledge sharing and relaying of information between the “Ukraine pool” team members, who are at the front line of crisis management, and the on-call team members pool, further away from the heat of the action. These sessions reinforce the engagement of the Institute’s employees and help to ensure the reactivity of all crisis pool teams in case of a serious event in Ukraine.

THE ACTIVATION OF AN INNOVATIVE “ACTIVE STANDBY” ORGANIZATION

On April 8, 2022, IRSN scaled back its watch system, while remaining available for its contacts. There were several reasons for this choice: the conflict was becoming entrenched and the tension around the Ukrainian nuclear sites, including Zaporizhzhya, was decreasing. The teams that had been highly involved over these weeks were also mobilized on national or international topics. IRSN’s approach had to be a long-term one.

In August, the Zaporizhzhya power plant was subject to particularly worrying repeated shelling. On August 22, IRSN decided to remobilize the team members of the “Ukraine pool”. It chose an innovative “active standby” format that was not envisaged in its organization. The objective was to mobilize the teams by setting up regular consultation meetings based on the situation briefings established by the four reactivated monitoring mechanisms (media, safety, environmental monitoring, international). Since then, every Monday, the Crisis Director has invited the facilitators of the “Ukraine pool” units as well as the main on-call team members who may be called upon “on the spot”, to give an overview of the week’s current events, to give briefings on the work in progress, to define the directions to take, the work to be initiated, and the documents to be produced in order to inform the public authorities and to keep the media and civil society in the loop. This simplified system has enabled IRSN to demonstrate a high level of reactivity when faced with six real events successively in less than 30 days in France, from September to mid-October, and to implement its program of crisis exercises and visits (see chapter: Crisis and Post-Accident of the 2022 Annual Report).

THE UNPRECEDENTED SET-UP OF AN "INTERNATIONAL" UNIT

An "International" unit created after the Fukushima-Daiichi power plant accident, rarely called upon in the context of national exercises, set themselves up at the ERC on February 25 to help collect and cross-check information for an objective insight into events. This unit is responsible for international ties with two types of contacts: the network of IRSN's historical technical partners and the network of institutional contacts.

It first organized and produced a daily international monitoring report, then a weekly one. After each attack on a nuclear facility, it closely monitored the situational self-appraisal information posted by SNRIU on two platforms administered by the IAEA: USIE, the unified system for the exchange of information in the event of an incident or emergency, and IRMIS, the international radiological control information system. It reported on the press conferences of IAEA Director General Rafael Grossi.



THE UKRAINE CRISIS HAS STRENGTHENED THE NEED FOR EXCHANGES WITH OUR TECHNICAL COUNTERPARTS AND OUR INSTITUTIONAL CONTACTS ABROAD

"For many years, and especially since the Fukushima-Daiichi accident, IRSN has been working with its counterparts in Europe and around the world to build common emergency response expertise, involving common risk assessment, technical assessment methods, and shared tools for assessments and release prognostics, etc. With a strong international presence in crisis management, the Institute has established partnerships with major emergency centers of technical bodies and safety authorities. It is therefore quite natural that, from the start of the events in Ukraine, we have established regular exchanges with our historical partners: GRS and BfS in Germany, US-DOE NNSA, as well as the US-NRC in the USA, STUK in Finland, SSM in Sweden and BelV in Belgium. The challenge was to understand everyone's levels of mobilization and preparedness, and to all be able to build a common assessment framework in order to support decisions of the public authorities in Europe should an event occur. These contacts led us to share technical products that we had not previously exchanged, and to check that everyone could use the technical data into their workflow.

We established the same type of exchanges with the IEC, the IAEA emergency center, although our relations had not yet been formalized. The IAEA had specific technical questions about the risks associated with the Ukraine situation. The Institute provided it with safety analysis data.

Also in the context of the Ukraine crisis, we have had discussions with WENRA, the association of safety authorities in Western European countries, chaired in 2022 by the ASN. We participated in meetings with the European Commission, giving rise to an inter-comparison report of expert capacities on a European scale to achieve enhanced integration."



Olivier Isnard,
Deputy Executive Director,
interfacing with the international
information networks



As part of a process of transparency and openness to society, IRSN has been heavily involved in responding to media requests and the specific queries of other stakeholders in civil society. The Institute has published educational, technical, and scientific briefing notes and news briefs. New in-house communication initiatives enable employees to stay informed of the situation and of the actions taken by the Institute.

A COMMUNICATION TEAM IN A STATE OF ALERT

From the start of the conflict, IRSN's communication department was on alert. The teams set up a media watch on the threats of a war. Media pressure was stepped up on February 24. To respond to these initial requests, IRSN decided to activate the crisis organization in standby mode before officially setting up the ERC on February 25. Immediately, the "Communication" unit put in place the "Ukraine special" media watch mechanism, integrating all social networks and conventional media in France and abroad. To keep the ERC teams updated on events, it produced one or more daily summaries, depending on the current situation. Highlighting areas of concern among elected representatives, associations, the workforce and citizens, this media watch guided IRSN's decision-making on technical assessments to be launched or thematic language elements to be developed.

OPEN AND EDUCATIONAL INFORMATION IN RESPONSE TO MEDIA PRESSURE

Over the next few days, journalists' questions came in thick and fast. Two spokespersons were chosen: one to answer questions relating to safety, and the other to address radiation protection/health issues. Their number was deliberately kept to a minimum due to the volatility of the events, which required in-depth knowledge of a subject in constant evolution.

The Communication team managed the technical information produced by the ERC to answer as clearly and simply as possible the questions that kept recurring: What nuclear facilities exist in Ukraine? What is the condition of these power plants (technology, robustness, safety status, etc.)? What is the radiological situation? Is there a risk? If so, what kind of risk?

Once the ERC produced a briefing note, the Communication Department disseminated it and promoted it internally and, where appropriate, in the media and on the Institute's website (irsn.fr).

The press office investigated all media requests and, in conjunction with IRSN experts, followed up on them.

Once established, this process continued: producing, transmitting, publishing, informing, and answering media questions.

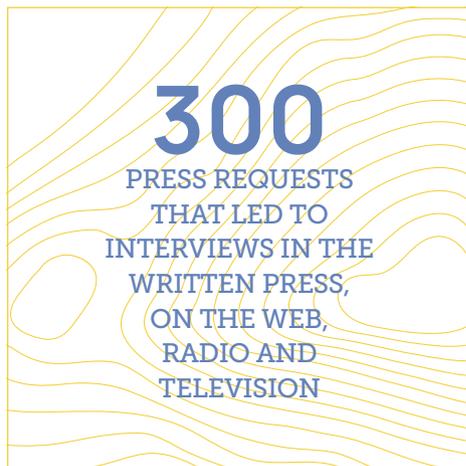
Media pressure peaked on several occasions. The experts were particularly solicited for the events of February 24, March 4 and March 9, in an unprecedented context of information warfare, then again in August and early September when the IAEA mission to Zaporizhzhya submitted its inspection report.

PROCESSING MANY OTHER REQUESTS

The communication department also received requests from other actors, sent directly or via other IRSN departments. These requests came from the HCTISN (High Committee for Transparency and Information on Nuclear Safety), from associations (CLIs, ANCCLI, CRIIRAD, Greenpeace, etc.), from NGOs, and even from companies that want to know what radiation protection measures and equipment are needed for their employees. Here are a few examples:

- *Médecins Sans Frontières/Doctors Without Borders (MSF)* requested training support for its teams departing for Ukraine.
- *France Télévision* asked for recommendations on the equipment of its journalists and filming teams who were shooting the evening news in the city of Lviv, in Ukraine.
- CRIIRAD asked questions about IRSN's assessments.

Each time, the ERC studied the request, defined the Institute's position, and determined which expert contact to assign for the response.



REINFORCED INTERNAL COMMUNICATION TO LEVERAGE COLLECTIVE STRENGTH

As soon as the ERC was activated, an internal message informed all employees of the situation. It announced the setting up of the crisis organization, explained that the Institute had been called upon and mobilized for the war in Ukraine, and that it had moved into operation to produce expert assessments and provide support to the public authorities within the framework of its missions.

The internal communication teams reported statements, as well as the media coverage. This regular flow of information allowed employees to be given insight into the events.

Nevertheless, the war continued to rage. IRSN needed to strengthen its internal communication. If a serious event occurred in Ukraine, all employees would serve as spokespeople for the Institute with regard to their family, circle of acquaintances, and the outside world.

In addition, the management of this long-term crisis required more and more employees – not always members of the crisis pool – to carry out expert assessments. IRSN wanted to promote this new cross-functional and collaborative dynamic. To do so, the Institute launched two new initiatives in September:

- **Two internal webinars.** These Teams conferences were attended by almost 500 employees. The presenters explained the nature, depth, and scope of IRSN's work as part of its missions, with a focus on safety assessments of Ukrainian facilities, the problem of losing power supply, the environmental monitoring system in place, exchanges and modes of cooperation with SNRIU, and investment in communication.
- **Four internal videos: "Everyone mobilized"!** These short films showcased the first-hand accounts of experts invested in crisis management, even though they are not part of the on-call team of IRSN's crisis organization. By showing multifaceted mobilization, the films promoted the Institute's collective strength and the power of collaborative work.





AND AFTERWARDS...

The Ukrainian crisis, on the European continent, pursuing a dynamic that no scenario had envisaged, is very different from that of the Fukushima-Daiichi power plant which, in 2011, had driven IRSN to set up the ERC around the clock for a period of several weeks. The Japanese crisis, unlike other major international crises in the history of civil nuclear power and safety, was linked to a severe accident that simultaneously affected several reactors on the same site. In Ukraine, no reactor suffered critical damage in 2022. Nevertheless, a latent radiological risk, linked to acts of war targeted against facilities scattered over a large territory or against the energy infrastructure, has left a lasting threat over Ukraine and neighboring countries. This led IRSN to remain mobilized or on active standby for 10 months in 2022: an unprecedented situation. Given that the war is ongoing, the Institute will continue to monitor the nuclear facilities and the environment in Ukraine, Europe, and France for as long as necessary in 2023.

At the same time, feedback from this atypical crisis is already forthcoming. Indeed, the analysis of events affecting nuclear facilities always teaches us important lessons for improving safety and crisis management. Repeated attacks on the Ukrainian nuclear sites, along with the recent Covid-19 health crisis, once again prove that the reality of a crisis challenges the imagination, and that crisis management plans, while very useful for organizing quickly in the event of an alert, can never predict everything. Nevertheless, even though the safety improvements for nuclear facilities implemented in Europe – and more specifically in Ukraine – following feedback from the Fukushima-Daiichi disaster were not designed to protect these facilities in wartime, they have contributed directly to the robustness of the power plants during this year of armed conflict. They have reduced the risk of a severe accident caused by the loss of external power supply.

The exceptional situation of the crisis in Ukraine has also led IRSN to seek outside-the-box responses to build its resilience by drawing on the ability of its multidisciplinary teams to adapt their efforts to the challenges. Internally, within the Institute, this crisis has been a catalyst for adaptation and transformation. Externally, it has reaffirmed the importance of IRSN's role as a technical expert providing support to the public authorities in the context of international crisis management.



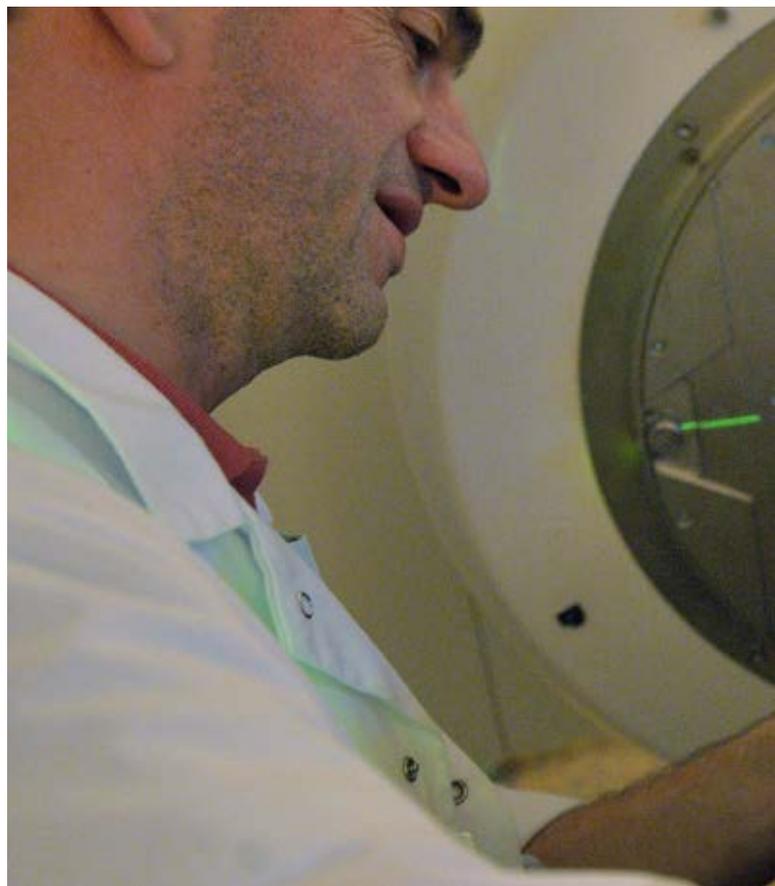
RADIATION PROTECTION FOR PEOPLE AND THE ENVIRONMENT

As one of the missions entrusted to it via the French Environment Code, IRSN carries out ongoing monitoring activities to assess human and environmental exposure to ionizing radiation. Each year, the Institute writes up its findings in reports and implements actions designed to improve the protection of people and biodiversity. This work enables us, for example, to gain a better understanding of the state of radioactivity, whether natural or linked to human activity, particularly near nuclear facilities, as well as the exposure of workers to ionizing radiation. As part of this approach, the Institute is also committed to equipping itself with tools for better assessing or controlling the emission of ionizing radiation. In 2022, for example, IRSN re-examined its environmental monitoring strategy and modernized the use of data related to this monitoring. In the medical field, several studies and analyses have been published, aimed at ensuring better protection of patients of all ages exposed to ionizing radiation for diagnostic or therapeutic purposes.

RADIATION PROTECTION OF PERSONS

A NEW NEUTRON DOSIMETER

Striving to continuously improve the quality of radiological monitoring of workers exposed to ionizing radiation, IRSN has developed a new version of its RPL-neutron dosimeter, which came into service in January 2022. The result of two years of R&D and user feedback, the new dosimeter is both stronger and lighter. It combines radiophotoluminescence (RPL) and neutron detection technology, enabling workers exposed to X-rays, gamma, and beta radiation, as well as neutron radiation, to be monitored in the course of their professional activities, mainly in industry or research. Its casing, 100% designed and produced by French companies, is made of recyclable plastic. It has a new, more ergonomic and robust attachment system. Alongside these innovations, IRSN is continuing its R&D work to produce a dosimeter offering even better metrological properties for the neutron component.



This guide is designed to be an easy-to-use, operational tool. It was developed to be suitable for use by all types of radiotherapy centers, regardless of their status or size. Each section of the guide, dedicated to a particular phase of the change-related project, is structured in a similar way around recommendations (on the organization, the resources to be allocated, the actions to be taken), accompanied by frequently asked questions to guide teams in the implementation of their project. In addition, the guide proposes inserts to illustrate concepts relating to organizational and human factors in order to flesh out the recommendations.

This guide provides professionals with recommendations from the field, supplemented by information to help understand what the recommendations are based on and questions aimed at guiding the professionals in their reflections.

AN OPERATIONAL SUPPORT GUIDE FOR RADIOTHERAPY PROFESSIONALS

At the request of the ASN, IRSN has drawn up a guide to familiarize radiotherapy teams with new equipment and techniques. In the context of rapid changes in treatment techniques using ionizing radiation, this document is designed to help healthcare professionals keep up to speed with these changes, which often go hand-in-hand with changes to their professional practices. The aim is to make it easier for radiotherapy professionals to understand and adopt state-of-the-art techniques while ensuring patient safety, and without adding significantly to their workload.

The drafting of this guide has mobilized various skills within the Institute, involving both medical physics and the organizational and human factors. After a data collection phase in different types of radiotherapy centers, IRSN experts, accompanied by an operational task force made up of healthcare professionals practicing radiotherapy, developed a guide organized according to the four major phases of a project for making modifications to radiotherapy equipment or techniques: project initiation, preparation for clinical deployment, deployment, and consolidating long-term appropriation of the innovation.





DIAGNOSTIC REFERENCE LEVELS IN MAMMOGRAPHY AND BREAST TOMOSYNTHESIS

In order to help optimize the radiological exposure of patients undergoing mammography or tomosynthesis mammography (a new technology that enables 3D breast images to be obtained by reconstruction from multiple cross-sections) as part of breast cancer screening, IRSN has worked, in response to an ASN referral, on updating or creating diagnostic reference levels (DRLs) for these examinations. DRLs are designed to help medical imaging practitioners optimize the exposure induced by radiological examinations, taking into account technological developments in the devices used and practices. DRLs constitute neither dose limits nor indicators of radiological risk. These levels are established on the basis of a technical analysis of the dosimetric data collected by IRSN and are updated periodically, in accordance with the French Public Health Code.

To this end, the Institute conducted a study based on data from 5,300 examinations performed on 80 "CR" mammography units with indirect scanning and 77 "DR" digital mammography units with direct scanning, and 3009 examinations performed on 44 tomosynthesis systems. Prior to January 2021, doses in digital mammography were assessed based on measurements taken as part of the external quality control of the devices. For "DR" units delivering lower doses for better image quality, the dose display on the mammogram now makes it possible to target a clinical collection of doses administered to patients and obtain up-to-date values.

Among the recommendations issued, IRSN proposes to take measures to avoid the commissioning of new "CR" mammography units, using an older technology delivering higher doses, and encourages the replacement of those in operation with newer "DR" mammography units.

With regard to tomosynthesis, which generates greater radiological exposure, IRSN proposes the creation of a DRL.

COLLABORATION WITH THE WORLD HEALTH ORGANIZATION (WHO)

IRSN had its role as a WHO collaborating center for radiation protection renewed in 2022 for a four-year term. This fourth consecutive renewal testifies to the WHO's recognition of the quality of IRSN's scientific and technical expertise. For the coming years, four priority work areas have been identified: medical and healthcare preparation and response to radiological and nuclear emergencies; mental health and psycho-social support in post-accident situations; the safe use of ionizing radiation in the medical field; and the health risk linked to existing exposure situations.

As part of this collaboration, IRSN contributed in 2022 to the development, critical review, and translation of various WHO recommendation documents: *"WHO stockpile policy advice"*, *"Handbook for health risk communication about food safety after radiation emergency"* and *"Communicating radiation risks in pediatric imaging: information to support health care discussions about benefit and risk"*.



**IRSN IS RENEWED
FOR THE 4TH
CONSECUTIVE
TIME AS A WHO
COLLABORATING
CENTER**

IONIZING RADIATION

The overhaul of SISERI (Information system for monitoring exposure to ionizing radiation), begun in September 2020 with the assistance of IRSN Lab - the IRSN innovation laboratory - is being finalized with the test phases of new features and interoperability by the various user communities: employers, accredited bodies, and operators.

This overhaul meets government expectations for the modernization and simplification of public services. The main objective is to optimize data consolidation in order to facilitate the traceability of worker exposure.

INTERCOMPARISON

The EIVIC project for whole-body counting intercomparison was completed in June 2022. Organized within the framework of the European Radiation Dosimetry Group (EURADOS^[1]) by IRSN, the project started in October 2019 and included 43 laboratories from 21 European countries. It consisted of six exercises for the identification and quantification of radionuclides in different internal exposure scenarios. This project made it possible to review the situation and test the technical capacities of the laboratories. All the technical information from these laboratories has been collated in a database that will facilitate exchanges between teams in the event of a large-scale accident.

MEDICAL ASSISTANCE MISSION FOLLOWING A RADIOLOGICAL ACCIDENT

IRSN intervened in September 2022, at the request of the IAEA, to coordinate a medical assistance mission and provide expertise in the management of a South American patient suffering from severe radiological burns following an interventional radiology procedure. The patient was admitted to the Percy Army Training Hospital in Clamart (Hauts-de-Seine) by a multidisciplinary team. He received surgical care combined with cell therapy treatment. This mission highlights once again the IAEA's recognition of French excellence in medical assistance.

[1] EURADOS: European Radiation Dosimetry Group comprising 80 European institutions and more than 600 scientists.



NEW KNOWLEDGE FOR PEDIATRIC RADIATION PROTECTION

In 2022, IRSN published a specific study of CT scan procedures carried out on children under the age of 16 in France between 2012 and 2018. In addition to periodic analyses of the medical exposure of the population carried out by the Institute, such as the ExPRI study, this study made it possible to assess in particular the changes in frequency of CT scan procedures in this particularly radiosensitive population. The results of this study first show a relatively constant annual frequency of computed tomography examinations (with an average of 14 procedures per year for 1,000 children) over the study period, with some variations depending on the age of the patients. The results then show a gradual transfer of certain CT procedures toward MRI, since these two imaging techniques have many common indications and the recommendations of professionals are pointing in this direction. In fact, the annual frequency of MRI procedures increased by 59% over the study period.

Also in 2022, new epidemiological results published as part of the "Child Scanner" cohort (launched in 2009 by IRSN to study the risk of radiation-induced cancer from exposure to computed tomography in childhood) confirm the low excess risk of leukemia and brain tumors. This cohort is part of the European EPI-CT project, the results of which show that the increased risk of developing this type of tumor according to the dose received by the child in the head area remains very low when set against the diagnostic benefits of CT scans.

EXPOSURE OF WORKERS TO IONIZING RADIATION

Every year, IRSN publishes its report on occupational exposure to artificial or natural sources of ionizing radiation in France. For 2021, 392,180 employees underwent dosimetric monitoring (a 1.2% increase in subjects compared to 2020). First, the IRSN report shows that the collective dose for all workers monitored in 2021 was 82.7 hSv (vs. 72.5 hSv in 2020). This increase of 14% concerns all areas of activity. Its main origin is the increase in the volume of maintenance work in the nuclear field, after less activity in 2020 due to the Covid-19 health crisis. For the same reasons, the average individual dose was 0.85 mSv, up 9%. With regard to the individual dose, 24,419 workers received an annual dose greater than 1 mSv (regulatory annual limit set for the general population) and, among them, 2712 workers received an annual dose greater than 5 mSv, including one medical worker who received a dose greater than the occupational exposure limit of 20 mSv. One case exceeding the effective dose equivalent limit on the skin (500 mSv) and a second on the lens of the eye (50 mSv) were also recorded.

As part of internal exposure monitoring, out of the 232,140 analyses carried out routinely in 2021, three workers presented a committed effective dose greater than or equal to 1 mSv. As in the previous year, this report is supplemented by thematic focus areas addressing in more detail certain aspects of exposure monitoring, for example in veterinary medicine or in nuclear fuel manufacturing facilities.





RADIATION PROTECTION OF THE ENVIRONMENT

A NEW GUIDE ON ASSESSING THE RADIOLOGICAL RISK ASSOCIATED WITH NUCLEAR FACILITIES

In January 2022, IRSN and ASN published a guide on assessing the radiological risk to wild fauna and flora near nuclear facilities. Entitled: "Methodological guide for the assessment of radiological risk to wild fauna and flora: Concepts, basic information and implementation within the impact study", this guide was drawn up by a multi-disciplinary and multi-stakeholder group, mirroring the profile of potential users of such a method.

This guide proposes a methodology to assess the level of protection of wild fauna and flora against their exposure to ionizing radiation, and more particularly, the assessment associated with releases from a facility which is operating normally. It provides tools that can be used to carry out environmental impact studies on nuclear facilities and activities.

IN BRIEF

ATMOSPHERIC EMISSIONS FROM CYCLOTRONS

To assess the radiological impact studies of cyclotron releases on populations, IRSN has defined a methodology to determine the expectations of such studies. Developed on the basis of feedback from recently processed files at the Institute, the document covers the main stages of a radiological impact study and details the key points impacting the quality of the assessment. This document is made available to operators to help them come up with a more realistic assessment of the impact on populations located in the immediate environment of a facility releasing radionuclides. Additional work has been carried out to define, at the request of the ASN, the technical requirements to be implemented by operators in order to assess their releases.

RADON

As part of the National Action Plan for Radon Risk Management (2020 - 2024), IRSN has published a report which identifies geographical sectors where the data is deemed insufficient, based on the various radon measurement campaigns in buildings and the geogenic radon potential^[2] map. This work will serve as a guide for future radon measurement campaigns in private homes.

[2] Geogenic radon potential: potential of rocks to produce and facilitate the transfer of radon to the atmosphere.

REPORTING THE RESULTS OF THE FIRST RADIOLOGICAL STUDY OF THE SITE (RSS)

The Institute held a public meeting, attended by more than 150 people, on March 9, 2022 in Saint-Maurice-l'Exil (Isère) to present the results of the environmental radiation study of the Saint-Alban Saint-Maurice-l'Exil nuclear power plant. This event was an opportunity for discussion with local stakeholders on the lessons learned from this innovative study undertaken by IRSN in 2019, to supplement ongoing monitoring of the plant's environment.

The main objectives of this RSS were to improve scientific knowledge on the impact of the plant's radioactive releases on its environment, authorized as part of its normal operation, to evaluate more realistically the exposure of neighboring populations taking into account local specifics, and to involve local actors in order to field their questions and provide them with clear answers. To this end, the Institute implemented sampling and metrology methods to detect trace radioactivity and measure the relative contribution of the nuclear facility in relation to the radiological background noise of the geographical area concerned.

During this three-year (2019 - 2021) study, more than 960 samples were taken from the different environments (land, water, atmosphere) and more than 1,200 analyses were carried out. Almost 270 people were interviewed to gather information on their dietary habits (composition of meals, percentage of local produce consumed, etc.) and their use of space and time (time spent in the area concerned, indoors and outdoors, etc.).

Among the initial lessons learned from this work, it appears that all the results obtained are consistent with the radiological activities expected in the environment of a nuclear power plant and with the measurements routinely

made as part of the radiological monitoring of nuclear power plants. Another strong point worth mentioning is this study's scientific interest, since it was able to validate, by measurement, evaluations based on calculation models, despite the very low levels of radioactive marking, which are by their very nature difficult to detect. Another noteworthy factor is the extent of participation by local stakeholders – local information commissions, elected officials, associations, local residents, farmers, utilities managers, etc. – which was key to the success of the operation. Co-constructing the study in conjunction with these actors – experts in local knowledge, data providers and/or sampling facilitators – significantly improved the field knowledge needed by the Institute and, by extension, the overall quality of the work carried out. In summary, the radiological study of the Saint Alban site provided an opportunity for dialogue with the population which enabled IRSN to assert its credentials locally as an actor capable of co-producing, with local stakeholders, scientific insight into the radiological influence of the power plant and the resulting exposure of local residents.

In addition to the public meeting, the results of the study were written up in reports, and a web tool, inspired by the work carried out with IRSN Lab, was specially developed for the occasion.

This participatory research approach was a prizewinner in the 2022 *Trophées de la participation et de la concertation* ("Participation and collaboration awards"). Each year, this event, organized by the *"Décider Ensemble"* ("Deciding Together") association, rewards innovative citizen participation and collaboration initiatives.



IMPROVING KNOWLEDGE OF ARTIFICIAL RADIONUCLIDES IN THE ENVIRONMENT

IRSN has published a knowledge synthesis relating to the basic levels, designated "background noise", of artificial radionuclides in metropolitan France. This work was based on many measurements made over time, including for the regional radiological observations conducted by the Institute from 2008 to 2018. This makes it possible to estimate the exposures of populations resulting from the presence in the environment of these radionuclides, which originate mainly from fallout from atmospheric testing of nuclear weapons carried out by the United States, the Soviet Union, the United Kingdom, China, and France from 1945 to 1980, and the fallout from the Chernobyl accident in 1986. Furthermore, this knowledge enables us to obtain a baseline from which it is possible to estimate the additional radiological activity due to authorized discharges from nuclear facilities operating normally as well as those that could result from an accident, an untimely discharge, or any other cause of an increase in this background noise.

The report shows that the background noise has decreased since the end of atmospheric fallout. Furthermore, while the spatial heterogeneity of the initial fallout tends to fade over time, measurements show that there are still limited areas of France where concentrations of radionuclides in soils and in certain types of foodstuffs can still be significantly higher than elsewhere, without however constituting any major health risk.



ENVIRONMENTAL MONITORING

During the review of its environmental radiation monitoring actions since 2009, IRSN presented an update of its monitoring strategy which underscores the utility of some of the previous objectives (maintaining monitoring networks in good condition, acting with reactivity and flexibility, maintaining its status as a metrology specialist, contributing to public policies) while adding new objectives: implementation of radiological studies of sites, adapting its monitoring in response to singular situations (nuclear incidents or accidents), and reinforcing data use. This work was presented to the High Committee for Transparency and Information on Nuclear Safety (HCTSIN) at its plenary meeting on October 18, 2022. In addition, the ODISCE committee submitted its first notice to the IRSN Director General on the involvement of society in this radiological monitoring on November 28, 2022 (see chapter "A responsible and civic-minded Institute").

BETTER USE OF ENVIRONMENTAL MONITORING DATA

The Institute has published the results of ongoing radiation monitoring across France, established on the basis of collecting and analyzing of its own data. The Institute has also undertaken to modernize the presentation of its annual environmental monitoring plan with the dual aim of making it more interactive for users and easier to understand in terms of the data collected.

The implementation of this monitoring plan fulfills the missions entrusted to the Institute by the public authorities. The plan is designed to monitor the evolution of radioactivity levels in the environment, near nuclear facilities, but also more generally throughout the country. This monitoring also makes it possible to analyze the impact of any events, in France or abroad. The results obtained show that the activity levels measured near the sites monitored remain relatively constant or on the decrease. Looking at metropolitan France as a whole, the activities measured are consistent with changes in environmental levels observed over the past several years.

All the results of the monitoring are accessible on the website of the French national network for environmental radioactivity measurements (www.mesure-radioactivite.fr).

In 2022, the Institute's teams also improved their operating tools, namely for producing statistics, and tools for representing data collected as part of IRSN's ongoing monitoring system.



Maxime Morin,
Head of Environmental
Analysis and Metrology

The update of the environmental radiological monitoring strategy of IRSN involved a wide range of knowledge and skills in environmental monitoring, analysis and metrology. This cross-functional exercise also involved data scientists and computer scientists.

Although the tool is still in the test phase, initial feedback on ease of access and meeting user needs is very positive.



CRISIS AND POST-ACCIDENT

In the event of a nuclear or radiological emergency, IRSN plays an active role in the national crisis response system and provides operational support to the public authorities by assessing the consequences of accidents on people and the environment.

In 2022, IRSN's efforts focused primarily on real-life situations. The year proved exceptional and unprecedented in several respects:

- Since February 25, the Institute has maintained its long-term investment in assessing the situation of nuclear facilities in Ukraine linked to the war taking place in that country, first by mobilizing its crisis organization and then placing it in "active standby" mode. Although IRSN has adapted its involvement as events have unfolded, not a week has gone by without the Emergency Response Center holding a meeting on this situation, unprecedented in so many respects (see the 360° Vision Bulletin).
- Between September 7 and October 6, the Institute had to activate all or part of its crisis organization in response to several incidents that occurred successively or simultaneously on French soil. Thanks to the reactivity of its crisis teams, IRSN was able to effectively fulfill its support missions for the authorities.

In parallel to this exceptional mobilization, IRSN has maintained its participation in a particularly dense program of national crisis exercises, for which it helps prepare the scenarios, as well as local crisis exercises, in conjunction with the operators who organize them, and internal crisis exercises.



8

CRISIS ORGANIZATION SET-UPS

CONTRIBUTING TO

25

EXERCISES:

- 11 LOCAL CRISIS EXERCISES
- 10 NATIONAL CRISIS EXERCISES EXCLUDING DEFENSE-RELATED ACTIVITIES
- 2 NATIONAL CRISIS EXERCISES ON DEFENSE-RELATED FACILITIES
- 2 IRSN INTERNAL EXERCISES

IRSN also participates in the development of post-accident doctrine. As such, the Institute has been a stakeholder, for several years, in the work of the CODIRPA^[1], led by the ASN. The purpose of this body is to make recommendations on strategy for managing the consequences of a nuclear accident, based in particular on feedback from the Fukushima-Daiichi accident.

IRSN is involved in the five CODIRPA 3 task forces (2020 - 2024) set up in 2022. In the last quarter, the Institute drew up two reports to feed into the work of the two task forces: "Contamination reduction and waste management strategies" and "Accidents other than those that may occur in a nuclear reactor".

IRSN is also a participant in the review of the National Response Plan for a Major Nuclear or Radiological Accident that the SGDSN (Secretariat-General for National Defence and Security) launched in mid-2022.

Lastly, the Interministerial Directive formalizing organization of the implementation of internal contamination measurements of persons in a radiological emergency with a view to possible healthcare was published on December 29, 2022 in the Official Journal. This directive reinforces the role of the Institute as a stakeholder and centralizing agency for measurements of individuals, and as advisor to the authorities on healthcare requirements and epidemiological studies to be implemented.

[1] CODIRPA: Steering Committee for the management of the post-accident phase of a nuclear accident or radiological emergency.



EXERCISES

IRSN PARTICIPATION IN NATIONAL NUCLEAR SECURITY EXERCISES

The Ministry of Energy Transition calls on IRSN's technical support for the preparation, organization, implementation, and evaluation analysis of annual security exercises.

One of them, called EPEES, is a nuclear security protection and evaluation exercise for operators, which aims, through the use of realistic scenarios, to assess the relevance of the operator's response to a malicious attack. In 2022, the exercise simulated an attack on the CEA center at Fontenay-aux-Roses (Hauts-de-Seine). Mandated by the HFDS (senior official for defense and security) of the Ministry of Energy Transition, the Institute devised and conducted this exercise (involving on average 200 to 300 participants, and requiring significant coordination) and, at the end, collected the feedback. IRSN's expertise in organizing such exercises – some fifteen to date – is recognized internationally.

IRSN also provided development support, in 2022, for a nuclear material transport exercise designed to test the emergency alert system, assistance provided to the public authorities, and a materials containment solution.

Lastly, IRSN participated in an inventory exercise for nuclear materials in crisis situations at the Orano site in Malvézi (Aude), where uranium oxide concentrate (yellowcake) is converted into uranium tetrafluoride (UF₄), ready to be enriched in uranium-235. The objective of this exercise was to assess the operator's response to the misappropriation of nuclear materials, through a simulated event leading to the initiation of an inventory of nuclear materials. A comparable exercise was held in April at the Framatome plant in Romans-sur-Isère (Drôme), a facility dedicated to the manufacture of fuels for research reactors.

Following each exercise, the Institute produced a report on the actions and the organization of the operators in these situations.

REAL-LIFE SITUATIONS

THE REACTIVITY OF IRSN'S CRISIS ORGANIZATION FOR TWO INCIDENTS

IRSN effectively fulfilled its role of supporting the authorities for two incidents occurring a few days apart.

On September 21, 2022, the Institute activated its crisis organization after having been informed of a fire in a workshop containing uranium at the Framatome plant in Romans-sur-Isère (Drôme), resulting in a risk of radioactivity spreading into the environment. Five days later, it reactivated its crisis organization after being alerted to an incident on the nuclear attack submarine *Perle* at the Toulon naval base (Var).

In both situations, in order to confirm the absence of radioactive releases into the environment around the sites concerned, IRSN dispatched experts and specialized vehicles to the site, in agreement with the ASN and the Drôme prefecture for the first case, and with the ASND and the Var prefecture for the second. Their direct *in situ* measurements of radioactive contamination and ambient gamma dose rate revealed no trace of abnormal radioactivity. The additional analyses that IRSN then carried out in its laboratories, using samples taken in the immediate vicinity of each of the sites, confirmed the absence of radioactive contamination. After laboratory analysis, the Institute published its results a few days after the event on its website www.irsn.fr.

PUBLIC INFORMATION IN AN EMERGENCY SITUATION

PROVIDING PUBLIC ACCESS TO DATA ON THE STATE OF RADIOACTIVITY IN THE ENVIRONMENT

In order to fulfill its mission to centralize radioactivity measurements in the environment in an emergency situation and provide feedback on them to the public authorities, IRSN had created a mapping website called CRITER in 2010. To contribute to its mission of transparency and informing the public in an emergency situation, IRSN developed the Webinforad application in 2022. This tool will offer the general public access to a compilation of raw data from the national Teleray radioactivity monitoring network and CRITER. The app will also enable IRSN to provide explanations, in a dedicated tab, in order to clarify the raw data. This tool will be tested during exercises in 2023.

POST-ACCIDENT

NEW CONTRIBUTIONS TO THE WORK OF THE CODIRPA (STEERING COMMITTEE FOR THE POST-ACCIDENT MANAGEMENT OF A NUCLEAR ACCIDENT)

In 2022, IRSN completed substantial work carried out within the framework of two CODIRPA 3 task forces.

The first task force worked on "Accidents other than those that may occur in a nuclear reactor". To provide data for this task force at the request of the ASN, and after work done on plutonium in 2021, IRSN drew up a report on uranium published in mid-December 2022. This report provides information on the behavior of uranium in the environment and in the human body, on the metrology of uranium, and on the routes of exposure contributing to the dose. Finally, it presents the elements to be considered in order to assess the robustness of the CODIRPA recommendations in the case of accidental uranium releases.

The second task force deals with "Contamination reduction and waste management strategies". In response to a request from the ASN, the Institute completed an initial analysis of feedback from the Chernobyl and Fukushima accidents in terms of actions to reduce contamination and the associated waste management. IRSN therefore analyzed post-accident waste management for a severe accident that causes long-term contamination to a widespread area. The report that the Institute published in September presents an up-to-date review of the definition of a typology of environments that may be affected by a nuclear accident as well as possible strategies for reducing contamination and managing waste. The second part, devoted to a case study, describes an accident scenario and the associated consequences, the simulated contamination reduction strategies and, lastly, the quantification of the waste generated and its possible management.

The IRSN teams have been involved in the other three task forces set up in 2022, whose work will continue in 2023, entitled respectively: "Development of a security and radiation protection culture around facilities", "Involvement of local actors in the management of the post-accident phase", and "Management of marine environments". This last group launched its work at the end of the year, co-managed by IRSN/ASN.



IN BRIEF

IRSN PARTICIPATES IN THE NATIONAL CRISIS MANAGEMENT PLAN REVIEW

IRSN is a contributor to the review, undertaken by the SGDSN, of the National Response Plan for a Major Nuclear or Radiological Accident established in 2014. Narrower in scope, the updated version will focus on the specifics related to the radiological and nuclear risk. It will incorporate feedback from the Fukushima-Daiichi accident and work done on the doctrines, particularly post-accident. The Institute is involved in the various task forces (communication, international, measurements, etc.) working mainly in 2023 and whose objective is to update the action sheets of the plan.



INTERNATIONAL

Whether for nuclear research or assessment, for nuclear safety and security, or for environmental or health monitoring, most of IRSN's activities involve partnerships, first and foremost in France, but also at a European or international level. Over time, the Institute has therefore built up a bilateral cooperative network, in particular with countries that have nuclear facilities, and a multilateral network, as part of its contribution to major international organizations such as the International Atomic Energy Agency, the OECD Nuclear Energy Agency, the World Health Organization, or the International Commission on Radiological Protection.

While the Institute's international exchanges were hindered in 2020 and 2021 by Covid-19-related restrictions, the lifting of these restrictions has enabled the reactivation of projects in progress and the launch of new ones. This renewed activity translated into intensive exchanges conducted between IRSN and its European partners, particularly within the framework of the European TSO network, ETSON and, beyond this, with our Japanese and Singaporean partners, to name just a few. The level of participation of the Institute at the 66th IAEA General Conference, attended by a delegation from the Institute led by the IRSN Director General, and the renewal of the safety research cooperation agreements in force with the United States Nuclear Regulatory Commission (US NRC) and that of Canada (CNSC-CCSN) also illustrate the Institute's international commitment, at the service, as always, of its scientific and technical excellence.

IRSN PARTICIPATES ACTIVELY IN THE 66TH IAEA GENERAL CONFERENCE

The IRSN Director General led a major delegation to this General Conference held in Vienna at the end of September 2022 and at which the DG spoke with the IAEA Director General, Rafael Grossi, and Lydie Evrard, in charge of nuclear safety and security.

The current situation of Ukrainian nuclear facilities was at the heart of the discussions between the representatives of the 171 Member States, focusing on the major challenges of the peaceful use of nuclear energy. In addition to this question, identified as a major issue by Rafael Grossi, Jean-Christophe Niel was able to address, during several one-on-one meetings, various subjects such as the safety of small modular reactors (SMR), the Institute's research projects concerning the safety of passive systems, and cooperation in terms of expertise between TSOs.

For their part, several IRSN experts participated in various side events at the Conference and took part in a series of one-on-one meetings with IRSN partners. The Institute organized a side event of its own, on the theme of research facilities dedicated to nuclear safety and radiation protection, attended by high-level representatives from various international organizations. In addition to the IAEA, participants included the OECD Nuclear Energy Agency (NEA), the European Commission, the European TSO ETSON network, and the European Association of Research and Technology Organizations (EARTO). They agreed on the need to ensure the sustainability of these research facilities, which are essential both for the advancement of scientific knowledge and for the training of young researchers. At the same time, the participation of the Institute's experts in other side events enabled them to present in particular the research activities carried out using the CABRI reactor, a facility that is one of the International Centers based on Research Reactors (ICERR), designated by the IAEA, and to present its involvement in training radiation protection officers at the Forum of Nuclear Regulatory Bodies in Africa (FNRBA).

Finally, in the field of health, the Director Generals of the IAEA and IRSN have agreed to extend their cooperation, as evidenced by the IRSN presentation at the scientific forum: "Nuclear Science for Health" on the theme: "Rays of hope: cancer care for all". The Institute also chaired a session of the Meeting of Senior Safety and Security Officers, on a subject related to proton therapy, a radiotherapy technique aimed at destroying cancer cells by irradiating them using a beam of protons rather than the photons used in conventional radiotherapy. At the IAEA, the commitment of IRSN lives up to the challenges faced by the international community in matters of nuclear safety.

IRSN AND ITS SINGAPOREAN PARTNERS INTENSIFY THEIR EXCHANGES

In 2015, IRSN and the National University of Singapore (NUS) signed a Memorandum of Understanding establishing scientific information exchanges, visits by researchers, and training of Singaporean experts in areas of common interest. Since then, the ties between the two organizations have continuously grown and strengthened within the framework of scientific cooperation relating to three themes: radiochemical measurements and environmental metrology, radiobiology, and the safety analysis of nuclear facilities. It is against this backdrop that an IRSN delegation took part in a workshop at the National University of Singapore/Singapore Nuclear Research and Safety Initiative (NUS/SNRSI) in June 2022. Then, in September 2022, a delegation from NUS/SNRSI and the Singapore Energy Market Authority (EMA) visited various IRSN nuclear safety and radiation protection research facilities in Cadarache (Bouches-du-Rhône). During its visit to France, the Singapore delegation also visited the IRSN site at Fontenay-aux-Roses (Hauts-de-Seine), where it was given a presentation of the Institute's research and assessment approach in the field of atmospheric dispersion models and its crisis management organization, illustrated by a visit to the Institute's Emergency Response Center.

At the invitation of the EMA, an IRSN delegation went back to Singapore at the end of October to participate in the first day of Singapore International Energy Week. In a session entitled: "Accelerating low-carbon solutions", the Director General of IRSN outlined the safety challenges associated with innovative nuclear energy technologies – including small modular reactors (SMR) – which are being considered as a response to current climate, energy, and geopolitical challenges. Lastly, at the 5th meeting of the ASEAN Network for Nuclear Power Safety Research (ASEAN/NPSR), organized this year by NUS/SNRSI, the Director General of the Institute presented the ETSON network of European TSOs and its work.

As evidenced by these cross-visits, NUS/SNRSI and IRSN wish to further strengthen their strategic collaboration in the coming years, for the mutual benefit of both organizations.

VIKTORIA, OR HOW TO LEVERAGE EXPERIMENTAL PLATFORMS IN SCIENTIFIC COOPERATION

In 2022, several visits were made to the Cadarache site (Bouches-du-Rhône) by foreign delegations, where IRSN runs various experimental platforms, testifying to the scientific benchmark role that these represent for the Institute's partners. The German TSO GRS – with which the Institute maintains bilateral cooperation, including namely staff exchanges – visited the following platforms: GALAXIE (research into the fire risk in nuclear facilities), CHROMIA (radiochemistry research), MIDI (study of the dewatering of spent fuel pools) and ASPIC (study of the effectiveness of a spray system to cool a partially or totally dewatered fuel assembly). Other partners, such as the VTT Technical Research Center of Finland or the Slovakian engineering company VUEZ, also visited Cadarache to observe the operation of various IRSN research platforms.

The role played by these platforms in the development of scientific cooperation is illustrated perfectly by the relationship between IRSN and various Slovak nuclear safety stakeholders, in particular VUEZ engineering, with which the Institute built the VIKTORIA test loop located in Levice (Slovakia).



For 20 years now, the two organizations have worked in cooperation on the problems of cooling nuclear reactors in case of an accident. This cooperation is centered on the VIKTORIA test facility, built over 10 years ago as part of a joint investment and which has enabled numerous tests to be carried out to better understand the physical phenomena likely to occur during accidents involving the loss of reactor core cooling. This collaboration – and, more broadly, the importance for countries where nuclear reactors are operated to possess and share research tools devoted to nuclear safety – was at the heart of discussions conducted between IRSN and its Slovakian partners (VUEZ, the VUJE TSO, the UJD safety authority and the State Secretariat for Energy) during Jean-Christophe Niel's visit to Slovakia in April 2022. This dialogue continued in June, during a visit to France by the Secretary of State for Energy of the Ministry of the Economy of Slovakia, Karol Galek, during which the Director General of the Institute proposed additional collaborations with the Slovak organizations on the various research platforms, in particular concerning the safety of small modular reactors (SMR).



324
BILATERAL
COOPERATION
AGREEMENTS
IN FORCE WITH
RESEARCH OR
EXPERT BODIES



44
COUNTRIES
CONCERNED
BY THESE
AGREEMENTS

FRESH MOMENTUM FOR IRSN'S BILATERAL COOPERATION

In 2022, the lifting of health crisis-related travel restrictions resulted in a renewed series of exchanges between IRSN and its international partners, particularly in terms of research and development. This momentum was boosted in particular by the French presidency of the European Union in the first half of the year, to which IRSN provided its contribution.

In recent months, four cooperative initiatives have been developed. First, in June, there was the visit to IRSN by experts from the Korean Institute of Nuclear Safety (KINS), during which experts from the Institute and those from the South Korean TSO swapped ideas on the methods and tools for assessing radiological discharges during a nuclear reactor accident. To this end, the Korean experts were trained in the use of Persan, a software developed by IRSN. In early July, the Director General of the Institute welcomed a delegation led by the President of the Polish Safety Authority (PAA), Łukasz Mlynarkiewicz, for technical exchanges focusing on training. In mid-July, Jean-Christophe Niel met up in Berlin with Inge Paulini, President of the German Federal Office for Radiation Protection (BfS), with which the Institute has frequent exchanges as part of the PIANOFORTE project. Following discussions on various topics, the two directors signed a letter of intent to confirm their joint desire to cooperate. At the end of August, in Washington, IRSN signed with the United States Nuclear Regulatory Commission (US NRC) the renewal of the Memorandum of Understanding (MoU) between the two bodies and, on September 1st in Ottawa, the renewal of the MoU between IRSN and the Canadian Nuclear Safety Commission (CNSC-CCSN), both perpetuating bilateral technical cooperation in the fields of nuclear safety research and regulation. At the end of November, IRSN's Director General also participated in the nuclear round table, chaired by the French President during his State visit to the United States, which promoted Franco-American cooperation in terms of nuclear safety expertise and research. The last quarter confirmed this renewed drive of cooperation, as illustrated by the various meetings organized in Japan in late 2022.

IN BRIEF

COOPERATION WITH JAPAN INTENSIFIES

From November 28 to 30, 2022, a delegation of IRSN experts visited Tokyo for the 4th IRSN-NRA-JAEA seminar. After two years without contact due to the health crisis, this seminar enabled the many attending experts to visit experimental facilities of the Japanese Atomic Energy Agency (JAEA), to review the needs for safety research, to examine the progress of ongoing collaborations, to outline new avenues for research and, last but not least, to relaunch researcher exchanges, which have helped foster very close ties between the two parties.

Jean-Christophe Niel visited Japan at the beginning of December, where he chaired the 72nd Committee on the Safety of Nuclear Installations (CSNI) of the OECD Nuclear Energy Agency. During his visit, he took part in a tour of the Fukushima-Daiichi nuclear power plant, the TEPCO (plant operator) Decommissioning Archive Center, and the Naraha Center for Remote Control Technology Development. This trip to Japan was also an opportunity for bilateral meetings with various Japanese partners, such as the NRA (Nuclear Regulation Authority), Chiyoda Technol (dosimetry), and the Fukushima Medical University (FMU). IRSN has agreed to continue current collaborative projects with the FMU, such as those related to thyroid cancer or the BEERAD and KERO ecotoxicology projects, and to organize future exchanges of research personnel.





A HIGHLY- COMPETENT, INNOVATIVE INSTITUTE

In order to adapt to the rapid changes in its environment and to meet the challenges of nuclear safety and radiation protection, the Institute has set itself targets in terms of performance, innovation and employer attractiveness. In 2022, buoyed by the end of the Covid-19 health crisis, the Institute boosted its transformation momentum within the framework of its *2030 Ambitions & Strategy* project.

The digital transformation program, refocused on achieving digital success, helps craft changes in IRSN's activities while sustaining its technological base for the long haul. Cataloging enables the Institute to capitalize more easily on its scientific and technical data.

New tools for strategic workforce planning contribute to developing IRSN's attractiveness as an employer and to maintaining the skills necessary for performing its expert assessment and research missions, in a context of changing expectations and employee practices.

Developing digital tools for the internal sharing of IRSN's assets and encouraging innovative collaboration methods such as communities of practices have triggered a shift towards a learning organization, while support for teams from IRSN Lab are inventing forms of value-creating facilitation.

Lastly, IRSN is continuing its mission to build on its capital of knowledge and share the skills of its experts through the training it provides at *IRSN Academy*, its external training brand.

QUALITY

RENEWAL OF QUALITY-BASED MANAGEMENT SYSTEM CERTIFICATION FOR AN EXTENDED SCOPE

Certified since 2007, IRSN has obtained the renewal of its ISO 9001 certification for the next three years. The quality-based management system is a structuring tool for the Institute's activities. Its scope now includes nuclear safety and radiation protection training by *IRSN Academy*. These were some of the strong points highlighted by AFNOR, the certification body: proper consideration of the needs and expectations of interested parties, the creation of communities of practices, and the commitment and professionalism of IRSN teams. There are four points of improvement to be addressed before the next audit, scheduled for 2023.

DIGITAL TRANSFORMATION AND INNOVATION

DIGITAL TRANSFORMATION: 29 PROJECTS FOCUSED ON ACHIEVING DIGITAL SUCCESS

The goal of IRSN's digital transformation strategy, launched in 2019, is to endow all IRSN employees with a high-performance hybrid and digital working environment. Following the publication in 2021 of IRSN's digital strategy and given the acceleration of digital issues, both within the Institute's environment and for its lines of business, it appeared necessary to update the procedures for implementing and managing the initial version of the digital transformation program.

Version 2.0, launched in 2022, is geared towards realizing concrete digital successes, assessed according to several criteria: stakeholder perception, technical success, operational performance, and strategic success. These successes are expected to contribute to the operational development of IRSN's activities and to sustain its technological base.

The program is made up of 29 projects developed to contribute to the continuation and compliance of activities, to the prerequisites for transformation, and to strengthening the Institute's positioning in its ecosystem. It incorporates a set of guiding principles for the direction and management of these projects, a budgetary commitment, and governance procedures.

The projects selected cover the fields of research, expertise, functionality, and digital commons. Examples include the redesign of the SISERI application (Information system for monitoring exposure to ionizing radiation), the PEPS jobs plan management project, the new version of the CRITER mapping website, published in 2011 by IRSN to report on the results linked to the Fukushima event, the website for centralizing radioactivity measurements in an emergency situation, and the future [irsn.fr](https://www.irsn.fr) site.



IRSN DATA CATALOGING

IRSN has implemented a first governance component for its data, as part of the rollout of its data use and optimization strategy, by compiling an inventory of the main scientific and technical data at its disposal. This indexed inventory is available in the data catalog, currently made up of more than 200 data records and accessible to all employees who complete and enrich it on an ongoing basis. An internal tool for sharing the existing data assets, this catalog makes it easier to identify any that are eligible for Open Data. It is also used to populate external catalogs such as the interministerial catalog of data or the environmental data of Green Data for Health, an initiative of the 4th National Health Environment Plan and to which the Institute regularly contributes.

IRSN MODERNIZES ITS INTERNATIONAL NUCLEAR MATERIAL ACCOUNTING SYSTEM TO PARTIALLY AUTOMATE FRANCE'S NON-PROLIFERATION COMMITMENTS

With support from the Government as part of the *France Relance* program, IRSN launched the development of its Euratom Accounting Integration software in the Base for the Preparation of Reports on Safeguards (ICEBERG) in 2022. It aims to modernize, in terms of both functionalities and development technologies (programming language, operating systems, etc.), the processing of data relative to international accounting declarations for nuclear materials present in civil nuclear facilities in France. IRSN, which uses the accounting to support French authorities in the field of nuclear material non-proliferation, will have an optimized system for all its dedicated tools, thanks to ICEBERG. In particular, it will enable a data consolidation process to be set up and the associated tasks to be automated, such as the issuing of certain accounting reports that have so far been drawn up manually, the automatic verification of deliverables such as declarations, the recording of final reports, and long-term data storage. ICEBERG will also be equipped with comparison and query modules, enabling tedious analysis work to be automated.

ICEBERG will strengthen the Institute's ability to respond quickly to any request for expertise and will provide national authorities and international bodies with a global overview of the accounting data assets on nuclear materials, traceability of declarations, and the long-term availability of this data.



Laurent Guimier,
Head of IRSN Lab

IRSN Lab: Providing support for 30 new projects

Launched in 2020, IRSN Lab is an innovation and creativity laboratory that allows Institute employees to test out new methods of finding solutions to organizational, scientific, technical and societal challenges. In 2022, support from IRSN Lab led to the emergence of two high value-creating forms of facilitation.

First, support for research teams that request help from IRSN Lab at key points in their research projects. The innovation lab has often helped research teams lay the foundations of their project roadmap. By bringing all the stakeholders together around a table, it has facilitated the co-construction of a project's structural building blocks and the drafting of its overall organization. IRSN Lab has also supported teams whose project was already up and running, but who have reached a point in their research where they needed to step back and ask themselves where to go next. IRSN Lab has helped these teams to review the knowledge produced, questions left unanswered or new queries, identified obstacles and barriers, etc., in order to (re)prioritize their actions and the next steps in the research project.

Second, helping a team to define their needs when the time comes to launch a service. To start a service on a solid footing, clearly describing expectations is a fundamental step. IRSN Lab provides support in two stages. The first consists in running a "needs identification" session, provided for in the specifications and prepared in tandem with the service provider to fully understand the questions being asked. In the presence of the service provider, acting as observer, future users of the product explain their needs from different perspectives. This session can be completed by a workshop in "user test" mode at a time when the service provider has developed a prototype, mature but still modifiable, of its deliverable. Feedback and comments from future users allow the solution to be tweaked. These two support formats contribute to a significant increase in the efficiency of the service.



SUPPORT
PROVIDED TO
86
PROJECTS
SINCE THE
CREATION
OF IRSN LAB



719
EMPLOYEES
TAKING PART IN
AT LEAST ONE OF
THE 141 SESSIONS,
ORGANIZED FOR
THE MOST PART
REMOTELY

SKILLS DEVELOPMENT AND KNOWLEDGE SHARING

PROFESSIONAL DEVELOPMENT: FIRST DELIVERABLES OF THE TRA-G PROJECT

TRA-G (strategic workforce planning transformation) is a major cross-disciplinary project whose ambition is to maintain and develop skills within IRSN, in a context of evolving professional practices and changes to the internal and external environment. The project's collaborative work, initiated in 2020, has mobilized a wide range of employees around the redesign of the strategic workforce planning tools, with several objectives in mind: retaining employees by providing a clear picture of what their jobs entail today and what they may become tomorrow, strengthening internal and external mobility and employability, increasing IRSN's attractiveness as an employer, maintaining and developing skills, providing sound support, and promoting career development. In 2022, two new tools were rolled out:

- The new jobs repository, which provides a better understanding of the Institute's trades and professions and associated skills, and which aims in particular to give a clearer picture of potential career development.
- The 2023 annual jobs evaluation interview campaign was launched on Talentsoft, a more ergonomic HR platform. The new forms for these interviews, which are less time-consuming and more comprehensive in terms of content, make life easier for employees and managers, ensuring a more efficient dialogue.

DEVELOPING AND PROMOTING KNOWLEDGE POOLING

To evolve towards a learning organization, IRSN is developing knowledge-sharing tools and supports innovative collaboration methods.

Thanks to the Ask search engine, currently indexed to more than 400,000 internal and external resources, all IRSN employees enjoy easy one-stop access to information and business knowledge (assessment documents, repositories, scientific works, databases, international documents, IRSN intranet, etc.). Approximately 500 employees use Ask each month for automated information searches that are increasingly relevant to business needs. They use Ask as a tool for accessing IRSN's knowledge and sharing assets to enhance their expertise and research on a daily basis.

The communities of practices launched in 2021 to encourage skill-sharing and cross-functional exchanges within the Institute have shown considerable growth. Driven by dedicated facilitators and sponsors, 12 communities of practices, with at least 80 members each, have created learning spaces around a particular trade or profession, a subject of common interest, or an area of knowledge. Colleagues who did not know each other can now interact to improve their practices and optimize how IRSN works. A space for peer-to-peer learning and knowledge pooling the communities of practices create an environment of scientific and technical emulation in a climate of trust and mutual assistance. Through testing out innovative collaborative methods based on collective intelligence, they embody a new mindset and help in the transformation of the Institute.



Nathalie Bolteau,
Head of Skills and Learning Management

IRSN Academy: providing excellent external training

In 2022, for its first year of practice, IRSN Academy trained more than 400 trainees in France and abroad: medical imaging professionals, occupational physicians, industrialists, nuclear safety or environmental engineers who participate in the prevention or control of risks related to ionizing radiation in the course of their jobs. IRSN launched "IRSN Academy", its external training brand, in September 2021 with the goal of promoting safety and radiation protection. To this end, the Institute draws on the knowledge, skills and tools of its experts, who provide training in the fields of radiation protection, nuclear safety and security. In radiation protection, IRSN Academy's catalog includes all level I, level II, medical sector and industrial sector PCR (radiation protection specialist) training. Its initial certification training modules, lasting 8.5 days/54 h or 12.5 days/84 h depending on the options, are particularly rich in content. They combine theoretical teaching with practical work: visits, exercises, role play, use of devices. As for nuclear safety training, it is focused on highly specialized approaches, sophisticated calculation codes and platforms, such as SOFIA and SYLVIA, which the Institute has developed as part of its research or expertise work. IRSN Academy's catalog is regularly updated in line with developments in knowledge and regulations. Our ambition for 2023 is to maintain the high quality of these training courses – Qualiopi and OF PCR-certified by the Global Certification body – and to promote their excellence nationwide by means of targeted marketing.



FRANCE:
229
TRAINEES TRAINED
IN 32 SESSIONS



INTERNATIONALLY:
189
TRAINEES TRAINED
IN 13 SESSIONS

GOVERNANCE

BOARD AS AT JANUARY 1, 2023

ROLE

Through its deliberations, the Board settles IRSN's affairs. In particular, it discusses the general conditions of organization and operation, the institute's strategy and programs, and the annual report. It also approves the budget, amending budgets, the accounts for each financial year, and the allocation of results.

An MP

Natalia POUZYREFF, MP for the Yvelines Department

A senator

Stéphane PIEDNOIR, Maine-et-Loire senator

Ten State representatives

Christian DUGUÉ, nuclear safety inspector for the French Defense Procurement Agency, representing the Minister of the Armed Forces

Benoît BETTINELLI, Head of the Nuclear Safety and Radiation Protection Mission of the Department of Technology Risks, representing the Minister for the Environment

Joëlle CARMES, Deputy Director of Environmental and Food Risk Prevention, at the Directorate-General for Health, representing the Minister of Health

Guillaume BOUYT, Deputy Director for the Nuclear Industry at the Directorate-General for Energy and Climate, representing the Minister for Energy

Frédéric RAVEL, Scientific Director for the Energy, Sustainable Development, Chemicals and Processes sector at the Directorate-General for Research and Innovation, representing the Minister for Research

Arnaud GILLET, Head of the Risk Assessment and Management Office at the Directorate-General for Civil Security and Crisis Management, representing the Minister for Civil Security

Anne AUDIC, Deputy director for Work, Health & Safety Conditions at the Directorate-General for Labor, representing the Minister for Employment

Arnaud WIEBER, Head of the Energy, Participations, Industry, and Innovation Office at the Budget Department, representing the Minister for the Budget

François BUGAUT, Representative in charge of nuclear safety and radiation protection for defense-related activities and installations

Bernard DOROSZCZUK, Chairman of the French Nuclear Safety Authority (ASN)

Five advisory members

Marie-France BELLIN, Chairwoman of the IRSN Board. university lecturer and hospital practitioner in the Department of Diagnostic and Interventional Radiology of Bicêtre-Paul-Brousse hospital, nominated by the Minister of Health

Laurent MOCHÉ, CEO of Edenkia, nominated by the Minister for Energy

Fanny FARGET, Scientific Research Director at the CNRS (National scientific research center), nominated by the Minister for Research

Patrick DUFOUR, Auditor General of the Armed Forces on special assignment, nominated by the Minister for the Armed Forces

Ginette VASTEL, Doctor in pharmacology, nominated by the Minister for the Environment

Eight employee representatives

Nicolas BRISSON, CGT

Laurence FRANCOIS, CGT

Léna LEBRETON, CGT

Patrick LEJUSTE, CGT

David BOIREL, CFE-CGC

Sandrine ROCH-LEFEVRE, CFE-CGC

Annie CONSTANT, CFDT

Thierry FLEURY, CFDT

Six ex officio or associate members

Cédric BOURILLET, Director General for Risk Prevention and Government Commissioner

Jean-Pascal CODINE, Budget Auditor

Jean-Christophe NIEL, Director General of IRSN

Louis-Michel GUILLAUME, IRSN Deputy Director General in charge of defense-related missions

Isabelle FLORY, IRSN Accounting Officer

Cédric GOMEZ, secretary of IRSN's Works committee

SCIENTIFIC COUNCIL AS AT 25 MAY 2021

ROLE

The Scientific Council gives its opinion on IRSN's programs. It assesses their results and is able to provide recommendations on the direction of the institute's activities. It may be consulted by the Board's chairperson or by the supervisory ministers on any subject within the Institute's remit. Its opinion may be sought on any issue or project involving IRSN.

The Scientific Council meets twice a year in plenary session and may also meet, at its convenience, in a closed session, possibly extended to external experts in order to review a research theme or program more precisely.

Robert BAROUKI, Lecturer in Biochemistry at Paris University and Head of the Inserm T3S "Toxicology, Therapeutic Targets, Cellular Signaling and Biomarkers" Unit, Head of the Clinical Metabolomics and Proteomics Biochemistry Department at Necker Children's Hospital; Chairman of the Scientific Council

Jean-Christophe AMABILE, Chief Medical Officer, Full Professor at the Military School of Val-de-Grâce, Director of the French Defense Radiation Protection Service (SPRA)

Christine ARGILLIER, Research Director and Deputy Scientific Director of the AQUA Department at the French National Research Institute for Agriculture, Food and Environment (INRAE)

Bernard BONIN, Scientific Advisor for the Energy Division of the French Alternative Energies and Atomic Energy Commission (CEA)

Alain KAUFMANN, Director of the CoLLaboratory, a collaborative and participatory action research unit at Lausanne University (Switzerland)

Louis LAURENT, Scientific Director at the French National Research and Safety Institute for the Prevention of Occupational Accidents and Diseases (INRS)

Elsa MERLE, Lecturer at the PHELMA Engineering School of the Grenoble Institute of Technology

Michèle SEBAG, Research Director at the French National Center for Scientific Research (CNRS), Interdisciplinary Laboratory of Digital Sciences of Paris-Saclay University

Pierre TOULHOAT, Chairman of the Environment and Climate Change Division at the French National Academy of Technologies

Marc VERWERFT, Head of the nuclear fuels group at the *Studiecentrum voor Kernenergie* (Belgian Nuclear Research Center), Public Interest Foundation, SCK CEN (Belgium)

Denis VEYNANTE, Research Director at the French National Center for Scientific Research (CNRS), macroscopic molecular and combustion laboratory, CentraleSupélec, Deputy Director of the Open Data for Research Department of the CNRS

NUCLEAR SAFETY AND RADIATION PROTECTION RESEARCH POLICY COMMITTEE AS AT FEBRUARY 1, 2022

ROLE

The committee is an advisory body to the IRSN Board, giving opinions on research objectives and priorities in the fields of nuclear safety and radiation protection. It adopts a global approach that takes into consideration the requirements of society and public authorities - complementing the work of IRSN's Scientific Council - and focuses on the quality and relevance of the institute's research programs and outcomes from a scientific perspective.

PUBLIC AUTHORITIES

Supervisory ministry representatives

Martin RÉMONDET, Research and Innovation Department, representing the French Ministry of Ecological Transition
François-Xavier GOMBEAUD, Weapons Inspector for nuclear security, Armaments Inspectorate, representing the French Ministry of the Armed Forces
Fabrice LEGENDRE, Task Officer at the Policy and Supervisory Office, Directorate-General for Energy and Climate (DGEC), representing the French Ministry of Ecological Transition
Nomination pending, representing the French Ministry of Health and Prevention

Representing the French Directorate-General for Labor

Nomination pending, Head of the Physical Hazards Prevention Division, French Directorate-General for Labor

Representing the Nuclear Safety Authority (ASN)

Vincent CLOITRE, Director of the Office of the Director General of the ASN

COMPANIES AND PROFESSIONAL ASSOCIATIONS

Philippe LAURENT, Deputy Director of the Technical Department - Lyon, EDF
Bernard LE GUEN, Chairman of the SFRP (French radiation protection society)
Émilie LACROIX, Director of Safety and Environment, ORANO
Jean-Marc SIMON, Associate Lecturer, Hospital Practitioner, Radiotherapy-Oncology Department at Pitié-Salpêtrière Hospital
Sébastien CROMBEZ, Director in charge of Safety, the Environment and the Industrial Strategy (DISEF) of Andra

EMPLOYEES IN THE NUCLEAR SECTOR

Representatives of the national trade unions

Jean-Paul CRESSY, FCE-CFDT
Olivier CHAUMONT, FO
Patrick BIANCHI, CFTC
Jacques DELAY, CFE-CGC
Christian HOLBÉ, CGT

ELECTED REPRESENTATIVES

OPECST representatives

Philippe BOLO, MP for the Maine-et-Loire Department + one nomination pending

Representative of Local Information Commissions (CLI)

Nomination pending

Representatives of municipalities hosting a nuclear facility, proposed by the Association of French Mayors

Bertrand RINGOT, Mayor of Gravelines
Alain GALLU, Mayor of Pierrelatte

ASSOCIATIONS

Jean-Paul LACOTE, Representative of France Nature Environnement
Nomination pending, Board member of the *Ligue Nationale contre le Cancer*
Lionel LARQUÉ, Executive officer of the Alliance sciences-société (Alliss)

ADVISORY MEMBERS

Jean-Claude DELALONDE, Chairman of ANCCLI (French national association of local information committees and commissions)
Christine NOIVILLE, Chairwoman of the High Committee for transparency and information on nuclear safety (HCTISN)
Marie-France BELLIN, Chairwoman of the IRSN Board, university lecturer, hospital practitioner in the Department of Diagnostic and Interventional Radiology of Bicêtre-Paul-Brousse Hospital

RESEARCH ORGANIZATIONS

Philippe STOHR, Director of Nuclear Energy, representing the CEA
Cyrille THIEFFRY, Task Officer for Radiation Protection and Nuclear Affairs, IN2P3, representing the CNRS
Inserm, nomination pending
Étienne AUGÉ, Lecturer in physics, Assistant Vice-president of Paris-Saclay University, representing the French Conference of University Presidents (CPU)
Vincent LAFLECHE, Director of ParisTech, representing ParisTech

FOREIGN MEMBERS

Christophe BADIE, Department of Environmental Assessments *Public Health England*, UK
Ted LAZO, Nuclear Energy Agency (NEA), OECD

EX OFFICIO MEMBERS

Patrick LANDAIS, Atomic Energy High Commissioner
Cédric BOURILLET, Government Commissioner, represented by Benoît BETTINELLI, Task Officer for Nuclear Safety and Radiation Protection, French Ministry of Ecological Transition
Robert BAROUKI, Chairman of the IRSN Scientific Council
Jean-Christophe NIEL, Director General of IRSN

STEERING COMMITTEE FOR THE NUCLEAR DEFENSE EXPERTISE DIVISION (CODEND) AS AT MARCH 27, 2023

ROLE

The committee examines the program of activities prepared by the Nuclear Defense Expertise Division (DEND) within IRSN's Defense, Safety, and Non-Proliferation Division before it is submitted to the Institute's Board.

It is consulted when the Board is called upon to make decisions relating specifically to the organization or operation of this division and makes recommendations to the Board on matters related to DEND activities.

François BUGAUT, Chairman of CODEND, in charge of nuclear safety and radiation protection for defense activities and facilities

Thierry BURKHARD, General, Armed Forces Chief of Staff, represented by Rear Admiral Frédéric DREHER

Emmanuel CHIVA, Armaments General Representative, represented by Armaments General Engineer Christian DUGUE

Christophe MAURIET, Secretary-General for the Administration of the Ministry of the Armed Forces, represented by Captain Mokrane OUAREM

Général Nicolas LEVERRIER, Inspector of Nuclear Weapons, represented by Captain Pierre SULEAU

Mélanie JODER, Budget Director of the French Ministry of the Economy, Finance and Recovery (MEFR), represented by Arnaud WIEBER

Philippe BERTOUX, Director of Strategic, Security and Disarmament Affairs for the French Ministry of Europe and Foreign Affairs, represented by François COTTEL

Anne BLONDY-TOURET, Secretary-General, Senior Official for Defense and Security of the French Ministries of Economy and Finance, represented by Samuel HEUZE

Guillaume LEFORESTIER, Senior Official for Defense and Security of the French Ministry of Ecological Transition, represented by Mario PAIN

ETHICS COMMISSION AS AT APRIL 1, 2022

ROLE

The Ethics Commission is an advisory body provided for in IRSN's decree of organization. It is responsible for advising the Board on preparing the ethics policies applicable to the institute's activities and for monitoring their implementation, particularly as regards the conditions under which separation is ensured between expert appraisals carried out on behalf of government departments and those carried out for public or private operators. It also serves as a mediator when problems of an ethical nature arise.

Françoise ROURE, Chairwoman of the Commission, Inspector General, Chairwoman of the "Safety, Security and Risks" Section of the CGEJET (General Council of the Economy, Industry, Energy and Technology) and member of the Inspection Committee, PhD in Economics, specialty "International Economics", retired

Lionel BOURDON, Senior Medical Officer, Full Professor at the Military School of Val-de-Grâce. Scientific Director of the Institute for Biomedical Research of the Armed Forces (IRBA, Brétigny-sur-Orge), Director of the "research" component of the Armed Forces' "SSA 2020" Health Service Transformation Program, Professor holding the Armed Forces' Health Service research chair, retired

Raja CHATILA, Emeritus Professor of Robotics, Artificial Intelligence and Ethics at Sorbonne University, Paris. Her research covers several aspects of robotics in robot navigation, motion planning and control, cognitive and control architectures, human-robot interaction, machine learning and ethics. Member of the College of Ethics of the French Ministry of Higher Education, Research and Innovation, and member of Orange's Scientific Council

Marc CLÉMENT, Presiding Judge of the Administrative Court of Lyon, member of the Environmental Authority of the CGEDD (General council of the environment and sustainable development). Member of the Aarhus Convention's Implementation Committee (United Nations)

Alexandra LANGLAIS, CNRS researcher in environmental law, CNRS bronze medalist - Environmental research manager at the IODE (Western Institute: Law and Europe) - author of research and expertise documentation on the laws on waste, soil, water, etc. Also a member of the GDR NoST (Standards research network - science and technologies)

Mauricette STEINFELDER, Inspector General, member of the CGEDD (General council of the environment and sustainable development) and the Environmental Authority, retired

Éric VINDIMIAN, Rural Engineering, Water, and Forest General Engineer, specialist in the impact of toxic substances on the environment and health and in the assessment of public environmental policies, member of the Environmental Authority of the CGEDD (General council of the environment and sustainable development), retired

ODISCÉ COMMITTEE ON MARCH 22, 2023

ROLE

The ODISCÉ - Opening up and encouraging dialog with civil society on expert assessment - committee is an advisory body to IRSN's Director General, made up of experts and advisors of participation. Its objective is to encourage new scientific-society interactions on the appraisal of nuclear and radiation risks, to encourage regular and in-depth dialog, by broadening the audiences involved.

Michel BADRÉ, Chairman of the ODISCÉ committee, first chairman of the Environmental Authority and former EESC Vice-President, Chairman of the National Commission for Public Debate (CPDP) on^[1] "New reactors and the Penly project"

Évelyne ALLAIN, Director of the French Institute of Instructors in Major Hazards and Environmental Protection (IFFO-RME)

Isabelle BARTHE, Investigator Commissioner, Guarantor of the French National Commission for Public Debate (CNDP)^[2] and member of various National Special Commissions for Public Debate (CPDP)^[3] (PNGMDR^[4], New reactors and the Penly project)

Guillaume BLAVETTE, Representing France Nature Environnement (FNE)

Anne CHEVREL, Lecturer, consultancies in public consultation management and Director of Vox Operatio

Paul CHRISTOPHE, MEP North and Chairman of CLI^[5] of Gravelines

Marc CLÉMENT, Member of the Environmental Authority and vice-chairman of the Aarhus Convention's implementation committee

Élise COURCAULT, Head of Health Democracy & Living Lab at INCa^[6]

Sébastien FARIN, Director of Dialog and Foresight at Andra

Emmanuelle JANNÈS-OBBER, Deputy Head of the Open Science Department at INRAE^[7]

Cécile LAUGIER, Deputy Environmental Director of the Nuclear Production Division at EDF's Nuclear Production Department

Yves LHEUREUX, ANCCLI (French national association of local information committees and commissions)

Clément MABI, lecturer at UTC^[8], specialist in relationships between technological innovation and democracy, particularly in its participatory forms

Alima MARIE-MALIKITÉ, Director of the Office of the General Management of SPF^[7], in charge of openness and dialog with society

Yves MARIIGNAC, Head of the Nuclear and Fossil Fuels Division of the Néga-Watt Institute

Maité NOÉ, Deputy Mayor of Vinon-Sur-Verdon, Vice-Chairwoman of the Cadarache CLI^[9]

Christine NOUVILLE, Research Director at the CNRS, Chairwoman of the HCTISN^[8]

Marion ROTH, expert in citizen participation in communities, former Director of Décider ensemble

Yannick ROUSSELET, Independent Nuclear Safety Consultant, representing Greenpeace France in the Channel CLIs

Simon SCHRAUB, Doctor of Medicine and Social Sciences, Director and Vice-Chairman of the Ligue contre le Cancer (Bas-Rhine Committee)

Serge VIDAL, representing the CGT's National Federation of Mines and Energy

[1] CPDP: Special National Commission for Public Debate.

[2] PNGMDR: The French national radioactive materials and waste management plan.

[3] CLI: Commission locale d'information (Local Information Commission).

[4] INCa: Institut National du Cancer (National Cancer Institute).

[5] INRAE: Institut national de recherche pour l'agriculture, l'alimentation et l'environnement (National Research Institute for Agriculture, Food and Environment).

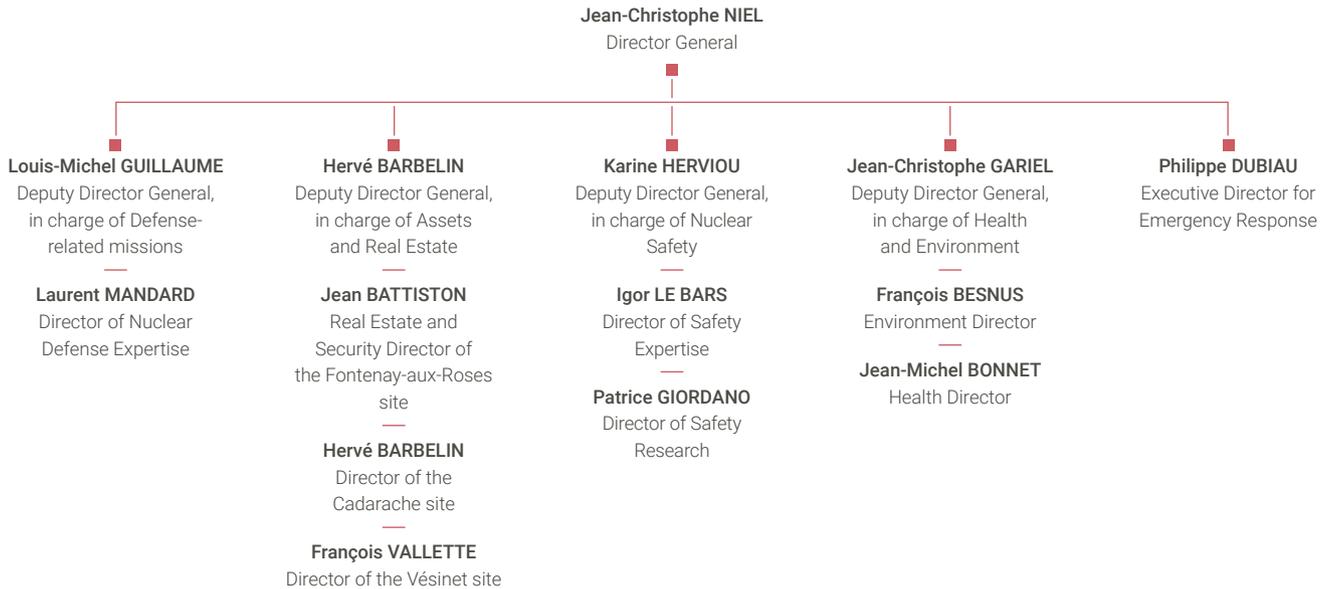
[6] UTC: Compiègne University of Technology.

[7] SPF: Santé Publique France (Public Health France).

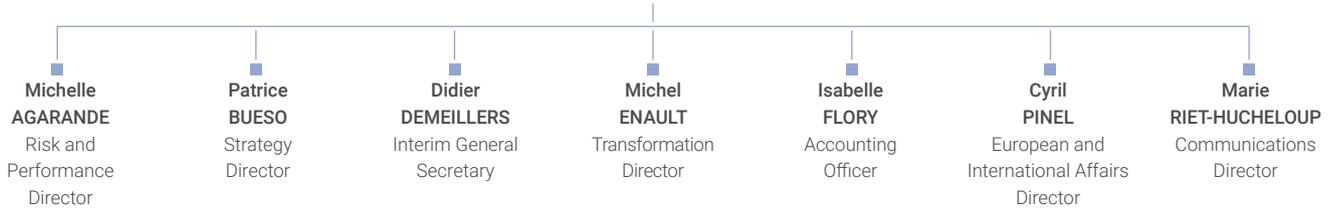
[8] HCTISN: High Committee for Transparency and Information on Nuclear Safety.

ORGANIZATION CHART

GENERAL MANAGEMENT



FUNCTIONAL AND SUPPORT DEPARTMENTS



From left to right: Hervé Barbelin, Jean-Christophe Gariel, Cyril Pinel, Marie Riet-Hucheloup, Michelle Agarande, Michel Enault, Patrice Bueso, Jean-Christophe Niel, Karine Herviou, Philippe Dubiau, Louis-Michel Guillaume, Didier Demeillers

GLOSSARY

A

ANCCLI: *Association nationale des comités et commissions locales d'information* (National association of local information committees and commissions)

Andra: *Agence nationale pour la gestion des déchets radioactifs* (National Agency for Radioactive Waste Management)

ANR: *Agence nationale de la recherche* (National research agency)

ASN: *Autorité de Sûreté Nucléaire* (Nuclear Safety Authority)

ASND: *Autorité de Sûreté Nucléaire de Défense* (Nuclear Defense Safety Authority)

B

BEGES: *Bilan des émissions de gaz à effet de serre* (GHG emissions calculation)

BelV: Belgian TSO - Belgian Nuclear Safety Agency

BfS: *Bundesamt für Strahlenschutz* – German Federal Office for Radiation Protection

BRGM: *Bureau de recherches géologiques et minières* (French geological survey)

C

CEA: *Commissariat à l'énergie atomique et aux énergies alternatives* (French Alternative Energies and Atomic Energy Commission)

CEPN: *Centre d'étude sur l'évaluation de la protection dans le domaine nucléaire* (Nuclear Protection Assessment Study Center)

CIGÉO: Industrial geological disposal center for high-level and intermediate-level long-lived radioactive waste

CLI: *Commission locale d'information* (Local information commission)

CNDP: *Commission nationale du débat public* (National commission for public debate)

CNPE: *Centrale nucléaire de production d'électricité* (Nuclear Power Plant)

CNRS: *Centre national de la recherche scientifique* (National Center for Scientific Research)

CODEND: Steering committee for the nuclear defense expertise division

CODIRPA: Post-accident phase management committee

COR: IRSN nuclear safety and radiation protection research policy committee

CRIIRAD: *Commission de recherche et d'information indépendantes sur la radioactivité* (Commission for Independent Research and Information on radiation)

CSR: Corporate Social and Environmental Responsibility

CTE: *Comité technique EURATOM* (EURATOM Technical Committee)

CWC: Chemical Weapons Convention

D

DOE: Department of Energy - USA

DRL: Diagnostic Reference Levels

DSND: Representative in charge of nuclear safety and radiation protection for defense-related activities and installations

E

EPR: Evolutionary power reactor - European pressurized water reactor

ERC: Emergency Response Center

ESA: European Space Agency

ETSON: European Technical Safety Organisations Network

Eurados: European Radiation Dosimetry Group

EURATOM: European Atomic Energy Community

G

GPEC: *Gestion prévisionnelle des emplois et des compétences* (Job & skills planning)

GRS: *Gesellschaft für Anlagen-Und Reaktorsicherheit* – Global Research for Safety

H

Hcéres: *Haut Conseil de l'évaluation de la recherche et de l'enseignement supérieur* (High Council for the assessment of research and higher education)

HCTISN: *Haut Comité pour la transparence et l'information sur la sécurité nucléaire* (High Committee for transparency and information on nuclear safety)

HDR: *habilitation à diriger des recherches* (Research director)

HEQ: High environmental quality

HFDS: *Haut fonctionnaire de défense et de sécurité* (Senior defense and security official)

HLW: High level waste (radioactive waste category)

I

IAEA: International Atomic Energy Agency

ICRP: International Commission on Radiological Protection

IEC: Incident and Emergency Center - IAEA

IER: Institute of Environmental Radioactivity (Fukushima University)

Ifremer: French Research Institute for Exploitation of the Sea

ILW-LL: Intermediate-level waste - long lived (radioactive waste category)

INSTN: *Institut national des sciences et techniques nucléaires* (French Nuclear Sciences and Techniques Institute)

IPCC: Intergovernmental Panel on Climate Change

IRSN Lab: IRSN innovation laboratory

ISFIN: *Institut des sciences de la fusion et de l'instrumentation en environnement nucléaires* (Institute for Fusion Sciences and Instrumentation in Nuclear Environments) (Aix-Marseille University)

ITEM: *Institut méditerranéen pour la transition environnementale* (Institute for Mediterranean Environmental Transition) (Aix-Marseille University)

L

LILW-SL: Low- and intermediate-level waste - short-lived (radioactive waste category)

LOCA: Loss-of-coolant accident

LSCE: *Laboratoire des sciences du climat et de l'environnement* (Laboratory for Sciences of Climate and Environment) (CNRS - CEA - Versailles-Saint-Quentin University)

M

MA: Marketing Authorization

MEF: Ministry of Economy and Finance in charge of non-proliferation

MNHN: *Museum national d'histoire naturelle* (National Museum of Natural History)

MOX: Mixture of plutonium oxide and uranium oxide – Nuclear fuel

MRI: Magnetic Resonance Imaging

MSF: Doctors without borders

MWe: Megawatt electrical – Measurement unit for the electrical power produced

N

NARAC: National Atmospheric Release Advisory Center - USA

NEA/OECD: Nuclear Energy Agency/ Organization for Economic Co-operation and Development

NGO: Non-Governmental Organization

NNSA: National Nuclear Security Administration - USA

NRC: Nuclear Regulatory Commission - USA

O

ODISCÉ: *Ouverture et impulsion du Dialogue avec la Société Civile sur l'Expertise* (Opening up and encouraging dialogue with civil society on expertise)

ONR: Office for Nuclear Regulation - UK

P

PWR: Pressurized water reactor

R

RCR: *Rapport de conclusion du réexamen périodique* (periodic review conclusion report)

RP4-900: Fourth periodic nuclear safety review of 900 MWe reactors

RP4-1,300: Fourth periodic nuclear safety review of the reactors of the 1,300 MWe series

RSNR: *Recherche en matière de sûreté et radioprotection* (Nuclear safety and radiation protection research)

S

SCC: Stress corrosion cracking

SFRP: *Société française de radioprotection* (French radiation protection society)

SGDSN: *Secrétariat général de la Défense et de la Sécurité nationale* (Secretariat-General for National Defense and Security)

SHFDS: *Service du haut fonctionnaire de défense et de sécurité* (Office of the senior official for defense and security)

SISERI: *Système d'information de la surveillance de l'exposition aux rayonnements ionisants* (Information system for monitoring exposure to ionizing radiation)

SMR: Small Modular Reactors

SNRIU: State Nuclear Regulatory Inspectorate of Ukraine

SSBN: Ballistic missile submarine

SSN: Nuclear attack submarine

SSTC: State Scientific and Technical Center for Nuclear and Radiation Safety - Ukraine

STUK: *Säteilyturvakeskus* – Nuclear Safety and Radiation Protection Authority, Finland

Sv: Sievert – unit of measurement for the impact of radioactivity on the human body

T

TSO: Technical Safety Organization

U

USIA: Unified System for Information Exchange in Incidents and Emergencies (IAEA)

V

VD4-900: Fourth ten-year nuclear safety inspection of 900 MWe reactors

VVER: *Vodo-Vodianoï Energueticheski Reaktor* – Russian designed pressurized water reactor

W

WENRA: Western European Nuclear Regulators' Association

THIS 2022 ANNUAL REPORT
WAS APPROVED BY IRSN'S BOARD
OF DIRECTORS ON MARCH 16, 2023

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ISSN No. OF THE ANNUAL
REPORT IN FRENCH
ISSN 2679-6783

DESIGN AND PRODUCTION

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