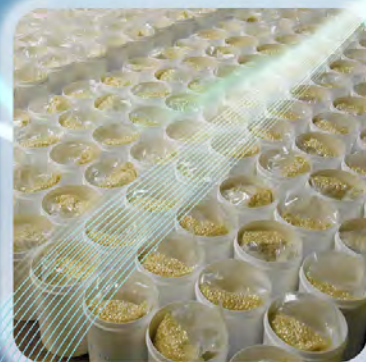


# IAEA ANNUAL REPORT 2022



**IAEA**

International Atomic Energy Agency

*Atoms for Peace and Development*

# Foreword by IAEA Director General Rafael Mariano Grossi



In 2022, the International Atomic Energy Agency focused on implementing both long-term and, in times of acute need, immediate assistance to its Member States.

When the facilities of one of Europe's largest nuclear power programmes faced an unprecedented threat generated by the war in Ukraine, the Agency reacted immediately. We closely monitored the nuclear safety and security situation in Ukraine and delivered assistance. Despite the war, Agency safeguards were implemented in Ukraine throughout the year, including in-field verification activities.

I led a number of Agency missions to Ukraine, as a result of which we have established an on-the-ground presence at all five of Ukraine's nuclear power plants. Since September 2022, I have exerted intensive diplomatic efforts to reach agreement on nuclear safety and security protection at Zaporizhzhya nuclear power plant in order to prevent a severe nuclear accident.

Despite the gravity of the situation in Ukraine, the Agency's attention was not diverted from other important work, in particular the provision of assistance to Member States tackling serious crises, from cancer and zoonotic diseases to food and energy insecurity.

At the African Union Summit in February, I launched the Agency's global cancer initiative, Rays of Hope, to help save lives and address the disproportionate burden of cancer. The initiative started out with 7 inaugural countries, and more than 50 countries are now interested in joining. We are forging new partnerships with governments, international financing institutions, the private sector and professional organizations.

By December, Zoonotic Disease Integrated Action (ZODIAC) — the Agency's initiative to combat zoonotic diseases — had made great strides, with 150 Member States having designated national coordinators and 126 having designated national laboratories.

In 2022, the Agency's integrated action plan for NUClear TEChnology for Controlling Plastic Pollution (NUTEC Plastics) outlined three major areas of action: assessment, planning and establishment of pilot plants for plastic waste recycling; marine microplastics monitoring and assessment; and outreach and partnership building.

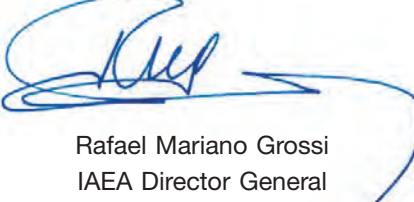
With the consequences of climate change being felt and countries prioritizing energy security, the case for low-carbon nuclear energy became even clearer in 2022. For a second successive year, the Agency revised up its annual projections for the potential growth of nuclear power in the coming decades.

Our prominent presence at COP27 in Sharm el-Sheikh, Egypt — particularly through the Agency's first-ever nuclear-themed pavilion and the launch of Atoms4NetZero — helped to ensure high visibility for nuclear power.

The Agency's Nuclear Harmonization and Standardization Initiative (NHSI) for the safe and timely deployment of small modular reactors was launched in June. Work began quickly, with 25 regulatory bodies and 30 companies working together under two tracks with the ultimate goal of harmonizing regulatory requirements and standardizing industrial approaches.

By the end of 2022, the proportion of women working at the Agency in the Professional and higher categories was more than 41%, the highest to date, and our Marie Skłodowska-Curie Fellowship Programme was in its third successful year of supporting women undertaking master's degrees in nuclear subjects. In the same vein, I announced the IAEA Lise Meitner Programme, which offers an opportunity for women to boost their career development in the nuclear field.

In what was a difficult year for many people across the world, the Agency once again made the most of its mandate and precious resources to help find solutions to national, regional and global challenges.



Rafael Mariano Grossi  
IAEA Director General

# IAEA ANNUAL REPORT 2022

Article VI.J of the Agency's Statute requires the Board of Governors to submit "an annual report to the General Conference concerning the affairs of the Agency and any projects approved by the Agency".

This report covers the period 1 January to 31 December 2022.

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# Member States of the International Atomic Energy Agency

*(as of 31 December 2022)*



|                                     |                                     |                                                            |
|-------------------------------------|-------------------------------------|------------------------------------------------------------|
| AFGHANISTAN                         | GERMANY                             | PALAU                                                      |
| ALBANIA                             | GHANA                               | PANAMA                                                     |
| ALGERIA                             | GREECE                              | PAPUA NEW GUINEA                                           |
| ANGOLA                              | GRENADA                             | PARAGUAY                                                   |
| ANTIGUA AND BARBUDA                 | GUATEMALA                           | PERU                                                       |
| ARGENTINA                           | GUYANA                              | PHILIPPINES                                                |
| ARMENIA                             | HAITI                               | POLAND                                                     |
| AUSTRALIA                           | HOLY SEE                            | PORTUGAL                                                   |
| AUSTRIA                             | HONDURAS                            | QATAR                                                      |
| AZERBAIJAN                          | HUNGARY                             | REPUBLIC OF MOLDOVA                                        |
| BAHAMAS                             | ICELAND                             | ROMANIA                                                    |
| BAHRAIN                             | INDIA                               | RUSSIAN FEDERATION                                         |
| BANGLADESH                          | INDONESIA                           | RWANDA                                                     |
| BARBADOS                            | IRAN, ISLAMIC REPUBLIC OF           | SAINT KITTS AND NEVIS                                      |
| BELARUS                             | IRAQ                                | SAINT LUCIA                                                |
| BELGIUM                             | IRELAND                             | SAINT VINCENT AND<br>THE GRENADINES                        |
| BELIZE                              | ISRAEL                              | SAMOA                                                      |
| BENIN                               | ITALY                               | SAN MARINO                                                 |
| BOLIVIA, PLURINATIONAL<br>STATE OF  | JAMAICA                             | SAUDI ARABIA                                               |
| BOSNIA AND HERZEGOVINA              | JAPAN                               | SENEGAL                                                    |
| BOTSWANA                            | JORDAN                              | SERBIA                                                     |
| BRAZIL                              | KAZAKHSTAN                          | SEYCHELLES                                                 |
| BRUNEI DARUSSALAM                   | KENYA                               | SIERRA LEONE                                               |
| BULGARIA                            | KOREA, REPUBLIC OF                  | SINGAPORE                                                  |
| BURKINA FASO                        | KUWAIT                              | SLOVAKIA                                                   |
| BURUNDI                             | KYRGYZSTAN                          | SLOVENIA                                                   |
| CAMBODIA                            | LAO PEOPLE'S DEMOCRATIC<br>REPUBLIC | SOUTH AFRICA                                               |
| CAMEROON                            | LATVIA                              | SPAIN                                                      |
| CANADA                              | LEBANON                             | SRI LANKA                                                  |
| CENTRAL AFRICAN<br>REPUBLIC         | LESOTHO                             | SUDAN                                                      |
| CHAD                                | LIBERIA                             | SWEDEN                                                     |
| CHILE                               | LIBYA                               | SWITZERLAND                                                |
| CHINA                               | LIECHTENSTEIN                       | SYRIAN ARAB REPUBLIC                                       |
| COMOROS                             | LITHUANIA                           | TAJIKISTAN                                                 |
| COLOMBIA                            | LUXEMBOURG                          | THAILAND                                                   |
| CONGO                               | MADAGASCAR                          | TOGO                                                       |
| COSTA RICA                          | MALAWI                              | TONGA                                                      |
| CÔTE D'IVOIRE                       | MALAYSIA                            | TRINIDAD AND TOBAGO                                        |
| CROATIA                             | MALI                                | TUNISIA                                                    |
| CUBA                                | MALTA                               | TÜRKİYE                                                    |
| CYPRUS                              | MARSHALL ISLANDS                    | TURKMENISTAN                                               |
| CZECH REPUBLIC                      | MAURITANIA                          | UGANDA                                                     |
| DEMOCRATIC REPUBLIC<br>OF THE CONGO | MAURITIUS                           | UKRAINE                                                    |
| DENMARK                             | MEXICO                              | UNITED ARAB EMIRATES                                       |
| DJIBOUTI                            | MONACO                              | UNITED KINGDOM OF<br>GREAT BRITAIN AND<br>NORTHERN IRELAND |
| DOMINICA                            | MONGOLIA                            | UNITED REPUBLIC<br>OF TANZANIA                             |
| DOMINICAN REPUBLIC                  | MONTENEGRO                          | UNITED STATES OF AMERICA                                   |
| ECUADOR                             | MOROCCO                             | URUGUAY                                                    |
| EGYPT                               | MOZAMBIQUE                          | UZBEKISTAN                                                 |
| EL SALVADOR                         | MYANMAR                             | VANUATU                                                    |
| ERITREA                             | NAMIBIA                             | VENEZUELA, BOLIVARIAN<br>REPUBLIC OF                       |
| ESTONIA                             | NEPAL                               | VIET NAM                                                   |
| ESWATINI                            | NETHERLANDS                         | YEMEN                                                      |
| ETHIOPIA                            | NEW ZEALAND                         | ZAMBIA                                                     |
| FIJI                                | NICARAGUA                           | ZIMBABWE                                                   |
| FINLAND                             | NIGER                               |                                                            |
| FRANCE                              | NIGERIA                             |                                                            |
| GABON                               | NORTH MACEDONIA                     |                                                            |
| GEORGIA                             | NORWAY                              |                                                            |
|                                     | OMAN                                |                                                            |
|                                     | PAKISTAN                            |                                                            |

The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957.

The Headquarters of the Agency are located in Vienna.

# The Agency at a Glance



**175**

**Member States**



**2556**

**professional and  
general service staff**



**€396.63**  
million

total Regular Budget for 2022\*

extrabudgetary expenditures in 2022

**€112.44 million**



**2** liaison offices  
New York  
Geneva

**2** safeguards  
regional offices  
Tokyo · Toronto



**149**

**countries and territories received  
support through the Agency's  
technical cooperation programme**

including **35** least developed countries



**15**

**international laboratories**

Vienna · Seibersdorf · Monaco



**11**

**multilateral conventions**

nuclear safety · nuclear security · nuclear liability

# 2022



## 1308

active technical  
cooperation projects



## 144

active coordinated research projects  
to develop new technology



## 189

States with safeguards  
agreements in force

of which **140**

States had additional  
protocols in force



## 62

active IAEA Collaborating Centres

designated Member State  
institutions supporting  
Agency activities



website

## 1 200 000

up 20% since 2021

visitors  
a month

social media

## 7 000 000

up 40% since 2021



Over **1 million**

items accessible through  
the Agency library



## 104

Agency publications in English

**98** in languages other than English

**14** newsletters

# The Board of Governors

The Board of Governors oversees the ongoing operations of the Agency. It comprises 35 Member States and generally meets five times a year, or more frequently if required for specific situations.

In the area of nuclear technologies, in the course of 2022 the Board considered the *Nuclear Technology Review 2022*.

In the area of safety and security, the Board discussed the *Nuclear Safety Review 2022* and the *Nuclear Security Review 2022*.

As regards verification, the Board considered the *Safeguards Implementation Report for 2021*. The Board considered the Director General's reports on verification and monitoring in the Islamic Republic of Iran in light of United Nations Security Council resolution 2231 (2015). The Board kept under its consideration the implementation of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) Safeguards Agreement in the Syrian Arab Republic and the application of safeguards in the Democratic People's Republic of Korea. The Board considered the issue of the NPT Safeguards Agreement with the Islamic Republic of Iran.

The Board discussed the *Technical Cooperation Report for 2021* and approved funding for the Agency's technical cooperation programme for 2023.

The Board considered reports on the Agency and the COVID-19 pandemic.

The Board considered nuclear safety, security and safeguards in Ukraine; IAEA safeguards in relation to AUKUS; and the restoration of sovereign equality in the Agency.

In June 2022, the Board recommended for approval by the General Conference the Agency's Draft Budget Update for 2023, and in December 2022, the Board recommended for approval by the General Conference a revision to the Budget Update.

The Board discussed and took note of the Agency's Medium Term Strategy 2024–2029.

*The Director General delivers his statement at the 1637th Board of Governors meeting held at the Agency headquarters in Vienna, 12 September 2022.*





## Composition of the Board of Governors (2022–2023)

Chair:

HE Mr Ivo ŠRÁMEK  
Governor from the Czech Republic

Vice-Chairs:

HE Mr Carlos Sérgio SOBRAL DUARTE  
Governor from Brazil

HE Mr Eoin O'LEARY  
Governor from Ireland

Argentina  
Australia  
Brazil  
Bulgaria  
Burundi  
Canada  
China  
Colombia  
Costa Rica  
Czech Republic  
Denmark  
Finland  
France

Germany  
Guatemala  
India  
Ireland  
Japan  
Kenya  
Korea, Republic of  
Libya  
Namibia  
Pakistan  
Qatar  
Russian Federation  
Saudi Arabia

Singapore  
Slovenia  
South Africa  
Switzerland  
Türkiye  
United Kingdom of  
Great Britain and  
Northern Ireland  
United States of America  
Uruguay  
Viet Nam



**89** reports considered

**135** hours of meetings

**1671** statements delivered





# The General Conference

The General Conference comprises all Member States of the Agency and meets once a year in regular session.

The Conference adopted resolutions on the Agency's financial statements for 2021; on the Agency's budget for 2023 (a subsequent special session of the General Conference approved a revision to the Agency's budget); on nuclear and radiation safety; on nuclear security; on strengthening the Agency's technical cooperation activities; on strengthening the Agency's activities related to nuclear science, technology and applications, comprising non-power nuclear applications, nuclear power applications and nuclear knowledge management; on strengthening the effectiveness and improving the efficiency of Agency safeguards; on the implementation of the NPT Safeguards Agreement between the Agency and the Democratic People's Republic of Korea; and on the application of Agency safeguards in the Middle East. The Conference also adopted decisions on the progress made towards the entry into force of the amendment to Article XIV.A of the Statute, approved in 1999; on the report on the promotion of the efficiency and effectiveness of the Agency's decision making process; and on the report on the restoration of sovereign equality in the Agency.



**2573** participants registered

**2317** Member State representatives

**101** from international organizations

**155** from NGOs

**1873** badges distributed



**140** General Debate statements delivered



**92** side events



**SF 414** Scientific Forum participants

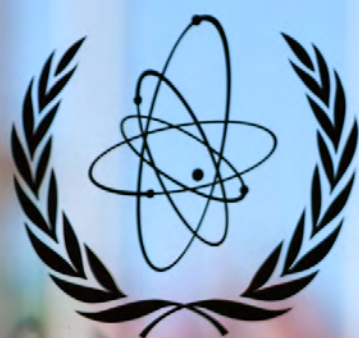


**12 381** livestream participants

*The Director General delivers his remarks at the opening of the IAEA 66th General Conference.*

# Notes

- The *IAEA Annual Report 2022* aims to summarize only the significant activities of the Agency during the year in question. The main part of the report, starting on page 53, generally follows the programme structure as given in *The Agency's Programme and Budget 2022–2023* (GC(65)/2). The objectives included in the main part of the report are taken from that document and are to be interpreted consistently with the Agency's Statute and decisions of the Policy-Making Organs.
- The introductory chapter, 'Overview', seeks to provide a thematic analysis of the Agency's activities within the context of notable developments during the year. More detailed information can be found in the latest editions of the Agency's *Nuclear Safety Review*, *Nuclear Security Review*, *Nuclear Technology Review*, *Technical Cooperation Report* and *Safeguards Statement and Background to the Safeguards Statement*.
- Additional information covering various aspects of the Agency's programme is available, in electronic form only, on [iaea.org](http://iaea.org), along with the *Annual Report*.
- The designations employed and the presentation of material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.
- The mention of names of specific companies or products (whether or not indicated as registered) does not imply any intention to infringe proprietary rights, nor should it be construed as an endorsement or recommendation on the part of the Agency.
- The term 'non-nuclear-weapon State' is used as in the Final Document of the 1968 Conference of Non-Nuclear-Weapon States (United Nations document A/7277) and in the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). The term 'nuclear-weapon State' is as used in the NPT.
- All the views expressed by Member States are reflected in full in the summary records of the June Board of Governors meetings. On 5 June 2023, the Board of Governors approved the *Annual Report for 2022* for transmission to the General Conference.



**IAEA**

International Atomic Energy Agency

# Abbreviations

|                |                                                                                                                                 |
|----------------|---------------------------------------------------------------------------------------------------------------------------------|
| <b>AFRA</b>    | African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology        |
| <b>ALPS</b>    | Advanced Liquid Processing System                                                                                               |
| <b>AP</b>      | additional protocol                                                                                                             |
| <b>ARASIA</b>  | Co-operative Agreement for Arab States in Asia for Research, Development and Training related to Nuclear Science and Technology |
| <b>ARCAL</b>   | Regional Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean          |
| <b>ARTEMIS</b> | Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation                      |
| <b>COMPASS</b> | IAEA Comprehensive Capacity-Building Initiative for SSACs and SRAs                                                              |
| <b>CPF</b>     | country programme framework                                                                                                     |
| <b>CRP</b>     | coordinated research project                                                                                                    |
| <b>CSA</b>     | comprehensive safeguards agreement                                                                                              |
| <b>EduTA</b>   | Education and Training Appraisal                                                                                                |
| <b>EENS</b>    | External Events Notification System                                                                                             |
| <b>EPR</b>     | emergency preparedness and response                                                                                             |
| <b>EPREV</b>   | Emergency Preparedness Review                                                                                                   |
| <b>FAO</b>     | Food and Agriculture Organization of the United Nations                                                                         |
| <b>ICERR</b>   | IAEA-designated International Centre based on Research Reactor                                                                  |
| <b>ICTP</b>    | Abdus Salam International Centre for Theoretical Physics                                                                        |
| <b>IEC</b>     | Incident and Emergency Centre                                                                                                   |
| <b>imPACT</b>  | integrated missions of PACT                                                                                                     |
| <b>INIR</b>    | Integrated Nuclear Infrastructure Review                                                                                        |
| <b>INIR-RR</b> | Integrated Nuclear Infrastructure Review for Research Reactors                                                                  |
| <b>INIS</b>    | International Nuclear Information System                                                                                        |
| <b>INLEX</b>   | International Expert Group on Nuclear Liability                                                                                 |
| <b>INMA</b>    | International Nuclear Management Academy                                                                                        |
| <b>INPRO</b>   | International Project on Innovative Nuclear Reactors and Fuel Cycles                                                            |
| <b>INSServ</b> | International Nuclear Security Advisory Service                                                                                 |
| <b>INSSP</b>   | Integrated Nuclear Security Support Plan                                                                                        |
| <b>IPPAS</b>   | International Physical Protection Advisory Service                                                                              |
| <b>IRRS</b>    | Integrated Regulatory Review Service                                                                                            |
| <b>IRRUR</b>   | Integrated Research Reactor Utilization Review                                                                                  |
| <b>ISAMZ</b>   | IAEA Support and Assistance Mission to Zaporizhzhya                                                                             |
| <b>ISCA</b>    | Independent Safety Culture Assessment                                                                                           |
| <b>ISSAS</b>   | IAEA State System of Accounting for and Control of Nuclear Material Advisory Service                                            |

---

|                           |                                                                                                                  |
|---------------------------|------------------------------------------------------------------------------------------------------------------|
| <b>JCPOA</b>              | Joint Comprehensive Plan of Action                                                                               |
| <b>KMAV</b>               | Knowledge Management Assist Visit                                                                                |
| <b>MCIF</b>               | Major Capital Investment Fund                                                                                    |
| <b>MEREIA</b>             | Methods for Radiological and Environmental Impact Assessment                                                     |
| <b>MSCFP</b>              | IAEA Marie Skłodowska-Curie Fellowship Programme                                                                 |
| <b>MSSP</b>               | Member State Support Programme                                                                                   |
| <b>NEM School</b>         | Nuclear Energy Management School                                                                                 |
| <b>NHSI</b>               | Nuclear Harmonization and Standardization Initiative                                                             |
| <b>NLO</b>                | National Liaison Officer                                                                                         |
| <b>NPCs</b>               | National Participation Costs                                                                                     |
| <b>NPP</b>                | nuclear power plant                                                                                              |
| <b>NPT</b>                | Treaty on the Non-Proliferation of Nuclear Weapons                                                               |
| <b>NUTEC<br/>Plastics</b> | NUclear TEChnology for Controlling Plastic Pollution                                                             |
| <b>NWAL</b>               | Network of Analytical Laboratories                                                                               |
| <b>OMARR</b>              | Operation and Maintenance Assessment for Research Reactors                                                       |
| <b>ORPAS</b>              | Occupational Radiation Protection Appraisal Service                                                              |
| <b>OSART</b>              | Operational Safety Review Team                                                                                   |
| <b>PACT</b>               | Programme of Action for Cancer Therapy                                                                           |
| <b>PROSPER</b>            | Peer Review of Operational Safety Performance Experience                                                         |
| <b>RANET</b>              | Response and Assistance Network                                                                                  |
| <b>RCA</b>                | Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology |
| <b>RCF</b>                | Regulatory Cooperation Forum                                                                                     |
| <b>RISS</b>               | Advisory Mission on Regulatory Infrastructure for Radiation Safety and Nuclear Security                          |
| <b>SALTO</b>              | Safety Aspects of Long Term Operation                                                                            |
| <b>SCCIP</b>              | Safety Culture Continuous Improvement Process                                                                    |
| <b>SEED</b>               | Site and External Events Design                                                                                  |
| <b>SIT</b>                | sterile insect technique                                                                                         |
| <b>SMR</b>                | small and medium sized or modular reactor                                                                        |
| <b>SQP</b>                | small quantities protocol                                                                                        |
| <b>SRA</b>                | State or regional authority responsible for safeguards implementation                                            |
| <b>SSAC</b>               | State system of accounting for and control of nuclear material                                                   |
| <b>TCF</b>                | Technical Cooperation Fund                                                                                       |
| <b>TSR</b>                | Technical Safety Review                                                                                          |
| <b>UPSAT</b>              | Uranium Production Site Appraisal Team                                                                           |
| <b>VETLAB<br/>Network</b> | Veterinary Diagnostic Laboratory Network                                                                         |
| <b>WHO</b>                | World Health Organization                                                                                        |
| <b>ZODIAC</b>             | Zoonotic Disease Integrated Action                                                                               |

---

# Overview

This chapter provides an overview of some of the programmatic activities that focused, in a balanced manner, on developing and transferring nuclear technologies for peaceful applications, enhancing nuclear safety and security, and strengthening nuclear verification and non-proliferation efforts worldwide.

Although the world was still experiencing the effects of the COVID-19 pandemic in 2022, the Agency continued to deliver on its mandate, with operations close to normal. The Agency also responded to Member States' requests for assistance in overcoming the consequences of regional or global medical emergencies, natural disasters, industrial accidents, and the armed conflict in Ukraine impacting the safe and secure operation of nuclear facilities.

Leveraging the Agency's approved projects distributed across the Departments, the Director General's initiatives, highlighted below, continued to be implemented through enhanced inter-Departmental coordination and in close cooperation with Member States and other interested partners, with a view to making greater impact in addressing global issues.

## Rays of Hope

Through Rays of Hope, an initiative launched in February 2022 by the Director General with President Macky Sall of Senegal at the African Union Summit, the Agency, in collaboration with Member States, strives to increase access to affordable, equitable, effective and sustainable radiation medicine services within a comprehensive cancer control system. Benin, Chad, the Democratic Republic of the Congo, Kenya, Malawi, the Niger and Senegal are among the first countries to have developed action plans under Rays of Hope to address existing needs and gaps (see related case study). In addition, long-term training and the procurement of radiotherapy and nuclear medicine equipment have been initiated. The Agency is engaging with Member States that have requested support to assess their needs and prepare respective action plans.



*The Director General and President Macky Sall of Senegal at the African Union Summit, February 2022.*



*Opening of the 2022 Scientific Forum on Rays of Hope: Cancer Care for All, September 2022.*



In December, the Agency partnered with 11 of the largest professional societies in cancer care, with the aim of strengthening the Agency's support to its Member States, particularly in the areas of capacity building in radiation oncology, medical physics and diagnostic imaging. Their expertise, educational resources and training will also be channelled through regional Rays of Hope 'anchor centres' to Member States on the ground. Anchor centres are designed to contribute to the sustainability and quality of care in the region.

The Agency and the World Health Organization (WHO), building on their long-standing collaboration, released a joint statement on 4 February 2022 on reducing inequity in access to cancer care through Rays of Hope.

High-level representatives and leading experts met at the Agency's 2022 Scientific Forum on Rays of Hope: Cancer Care for All to discuss how to establish and expand capacities to address cancer challenges at the national and global level. Participating in the forum, the WHO Director-General, the President of Malawi, the Minister of Health of Benin, the Secretary of Energy of the United States of America and the General Administrator of the French Atomic Energy Commission lauded the initiative. While Member States, in addition to non-traditional donors including private companies and development banks, have supported Rays of Hope through record financial contributions, intensive efforts are being made to mobilize sufficient resources with the aim of closing the funding gap.

## ZODIAC: Zoonotic Disease Integrated Action

As of December 2022, 150 Member States had designated national coordinators and 126 had designated national laboratories for the Agency's Zoonotic Disease Integrated Action (ZODIAC) initiative. In 2022, some 1000 participants from more than 95 Member States took part in virtual interregional training courses organized through the technical cooperation (TC) programme, and the first ZODIAC fellows from Indonesia, Senegal and Tunisia were trained in whole-genome sequencing at the Agency's Seibersdorf laboratories.

An initial in-person regional training course took place at the Institut Pasteur de Dakar in Senegal on the generic verification of standard operating procedures for new serological and molecular techniques.

Thirty ZODIAC national laboratories received serology and molecular diagnostic equipment and nine received whole-genome sequencing platforms.



*Opening of the ZODIAC workshop on mpox (monkeypox) and Lassa fever infections in animal reservoirs and the risks for public health transmission, held with WHO and FAO, June 2022.*

Four regional research projects were developed to enhance laboratory preparedness for the detection and control of relevant priority diseases for all regions.

Close coordination with WHO and the Food and Agriculture Organization of the United Nations (FAO) was strengthened.

Regarding ZODIAC's human health component, core research institutions were identified and a research project was initiated to characterize disease-specific patterns in patients infected by zoonotic diseases.

The ZODIAC Portal, an information and resource website offering educational videos and training materials, was launched and is attracting more than 1000 visitors each month.

## NUTEC Plastics: Nuclear Technology for Controlling Plastic Pollution

Since its launch in 2021, 78 countries have joined the Agency's Nuclear Technology for Controlling Plastic Pollution (NUTEC Plastics), engaging in upstream and downstream activities that include technology transfer via the Agency's TC programme and research and development through coordinated research projects (CRPs).

In 2022, an integrated action plan on NUTEC Plastics was published on the Agency's website, outlining three major areas of action: the assessment, planning and establishment of pilot plant(s) for plastic waste recycling; marine microplastics monitoring and assessment; and NUTEC Plastics outreach and partnership building.

Also in 2022, harmonized protocols for marine sediment and seawater sampling were developed, to be used by national laboratories during marine microplastics sampling campaigns in 2023.

The Agency launched a CRP on using ionizing radiation to recycle polymer waste for structural and non-structural materials. Seven countries are piloting the use of irradiation for recycling and three have advanced towards technology readiness level 3. Two meetings were held on strengthening the generation of bio-based products that could replace single use petrol-based products through radiation processing.

NUTEC Plastics was again included in a report by the G-20 and featured at the UN Ocean Conference in June 2022, attended by international experts, high-level officials, scientists and global leaders meeting to address ocean pollution, acidification, deoxygenation and warming.



*The Director General speaking at the UN Ocean Conference, June 2022.*

## Nuclear Harmonization and Standardization Initiative

The Nuclear Harmonization and Standardization Initiative (NHSI) was launched by the Director General in June 2022 to reflect the need for the harmonization of regulatory, and the standardization of industrial, approaches for small modular reactors. NHSI aims to advance the effective, safe and secure global deployment of advanced nuclear reactors, in particular small modular reactors, which are expected to play an important role in achieving net zero targets. Under NHSI, regulators, designers, operators and international organizations work together, consistent with respective roles and responsibilities, to harmonize regulatory and standardize industrial approaches.

At the NHSI kick-off meeting, 125 participants from 33 Member States and a number of international organizations reached a consensus on the general scope of the initiative. As a result, the Agency has started work in seven areas split into two tracks. Under the regulatory track led by the Department of Nuclear Safety and Security, the focus is on building an information-sharing framework, developing an international pre-licensing regulatory design review and developing processes to leverage other regulators' reviews. Under the industry track led by the Department of Nuclear Energy, the focus is on harmonizing high-level user requirements, developing common approaches for codes and standards, experiments and simulation codes' validation and accelerating the implementation of small modular reactor infrastructure.

The respective working groups met at least twice in the second half of 2022 to identify key challenges, prepare work plans to 2024, assign tasks and start drafting relevant documentation and discussing the development of information-sharing platforms.

In total, more than 25 regulatory bodies and 30 nuclear industry companies, as well as international and industry organizations, are participating actively in NHSI. An effective interface between the two tracks is ensured by the Agency through the continuous exchange of information and the participation of industry stakeholders in relevant activities under the regulatory track.



*NHSI kick-off meeting, June 2022.*

## IAEA Platform on Small Modular Reactors and their Applications

The IAEA Platform on Small Modular Reactors and their Applications aims to provide consistent and coordinated Agency support related to all aspects of small modular reactor development, deployment, and oversight.

During 2022, the Platform addressed seven requests for assistance covering a wide range of areas, including energy system analysis modelling for small modular reactor deployment, the role of such reactors in the energy transition, nuclear desalination using small modular reactors, and institutional, legal and regulatory aspects related to floating NPPs.

The Platform developed a medium-term strategy through 2029 to establish strategic objectives that ensure timely, relevant and consistent Agency contributions to address the needs and requests of Member States. These strategic objectives range from helping Member States to make informed decisions on the deployment of small modular reactors, to supporting the establishment of relevant frameworks and providing knowledge and technology transfer through technical cooperation. A high-level work plan is under development to implement these objectives.

A web portal for the Platform was launched to enable information exchange, outreach and networking, facilitate internal and external collaboration with Member States, and inform the public about the Agency's work on small modular reactors.

The Agency published a high-level booklet entitled *Small Modular Reactors: A new nuclear energy paradigm* developed within the framework of the Platform. The report addresses factors to be considered by Member States when deciding whether to adopt small modular reactors and how to enable their safe, secure, peaceful and sustainable deployment.

## IAEA Marie Skłodowska-Curie Fellowship Programme

The IAEA Marie Skłodowska-Curie Fellowship Programme (MSCFP) aims to encourage women to pursue a career in nuclear-related fields by providing highly motivated female students with scholarships for master's programmes and an opportunity to pursue an internship facilitated by the Agency. Between the programme's launch in 2020 and the end of 2022, a total of 360 students were awarded a scholarship.

The third round of applications closed on 30 September 2022, resulting in 150 selected students from 91 Member States who will be undertaking their studies in 48 countries. With the support of the MSCFP in 2022, 76 students completed their master's studies and 50 pursued internships facilitated by the Agency. The programme also launched the MSCFP Student and Alumni LinkedIn Group, where students have the opportunity to connect with their peers, exchange knowledge and experience, and access information about technical programmes and events that can benefit their personal and professional development.



According to MScFP recipient Carolina Gutiérrez Bolaños from Mexico, *“The MScFP programme will help more women enhance their education in nuclear-related fields, which is very important for present and future generations. We need to keep working together, women and men, to create opportunities for a more balanced workforce in nuclear. Both men’s and women’s creativity are needed to improve research in many scientific areas.”*

Beatrice Boatema, an MScFP fellow from Ghana, recalled that *“My dream of becoming a researcher and a consultant in nuclear engineering was nearly abandoned until I applied for the MScFP. My tuition and stipend were adequately paid, giving me peace of mind to concentrate on my studies. I could also afford books and other research materials.”*



Sara Ahmad from Portugal, another recipient of an MScFP fellowship, said that *“This programme allowed me to travel to a foreign country to complete my master’s and to entirely dedicate myself to my research project, where I worked among other qualified professionals in the nuclear field and had the opportunity to learn from them. I hope to apply my nuclear physics knowledge for medical purposes in my future career — preferably in medical physics research in hospitals or universities, especially the improvement of proton beam therapy and mitigation of its uncertainties.”*

## IAEA Lise Meitner Programme

The IAEA Lise Meitner Programme offers an opportunity for women to boost their career development in the nuclear field by enhancing their technical and leadership skills during a multi-week visiting professional programme hosted by partnering Member States. This new initiative was announced by the Director General in October 2022 at the International Ministerial Conference on Nuclear Power in the 21st Century.

## Nuclear Safety, Security and Safeguards in Ukraine

Since 24 February 2022, when information was received on the imposition of martial law on the territory of Ukraine and an alert at Chernobyl NPP, the Agency has established regular contact with the Ukrainian authorities and has been closely monitoring and assessing the situation in Ukraine, focusing on its implications for nuclear safety, security and safeguards.

Soon after the start of the armed conflict, the Agency formulated seven indispensable pillars for ensuring nuclear safety and security during an armed conflict (the ‘Seven Pillars’), which derive from and are aligned with IAEA safety standards and nuclear security guidance. Since their formulation, the Agency has used the Seven Pillars to tailor its independent and impartial assessment of the nuclear safety and security situation in Ukraine in the context of the ongoing armed conflict. Throughout the year, the Seven Pillars were either partially or fully compromised at almost all nuclear sites in Ukraine, in particular at Zaporizhzhya NPP (ZNPP).

Since the start of the armed conflict, the Agency has worked in a transparent, fact-based and authoritative manner by publishing relevant information on its 24/7 secure communication channel, the Unified System for Information Exchange in Incidents and Emergencies, issuing public statements and updates, publishing summary reports and issuing reports to the Agency’s Policy-Making Organs regarding the nuclear safety, security and safeguards situation in Ukraine. In 2022 the Agency issued 138 public statements, produced two summary reports on nuclear safety, security and safeguards in Ukraine (28 April and 6 September) and presented to the Board of Governors two oral briefings (March and June) and two detailed reports (September and November). The Board of Governors adopted by a vote three resolutions on the safety, security and safeguards implications of the situation in Ukraine, on 3 March, 15 September and 17 November.

The Agency drew up and agreed with Ukrainian officials a concrete and detailed technical plan for the provision of nuclear safety and security assistance to Ukraine in four areas: in-person technical assistance, delivery of equipment, remote assistance and rapid deployment assistance.

The Agency conducted nine in-person missions to Ukraine to help stabilize the situation, closely assess nuclear safety and security and assess corresponding needs. Three of these missions, including the IAEA Support and Assistance Mission to Zaporizhzhya (ISAMZ) in September 2022, when the continuous presence of Agency staff was established at ZNPP, were led by the Director General. The Director General paid two additional visits to Kyiv in 2022 to further assist in stabilizing the nuclear safety and security situation in Ukraine. In addition, the Agency arranged seven deliveries of nuclear safety- and security-related equipment to the country, intended for nine different organizations and comprising radiation monitoring and personal protective equipment, IT and communication equipment and portable power supply systems. Lastly, in 2022, the Agency agreed with Ukrainian officials that a continuous Agency presence would also be established at Khmelnytsky, Rivne, South Ukraine and Chernobyl NPPs. These missions were conducted with the support of the Department of Safety and Security and the Department of Operational Support of the United Nations Secretariat.

The Agency exerted intensive efforts to attain agreement on the establishment of nuclear safety and security protection around ZNPP with the aim of preventing a nuclear accident.

The Agency worked closely with Ukraine, Member States and international organizations to ensure efficient coordination and avoid duplication in the provision of technical support and assistance to Ukraine.

The Agency implemented safeguards in Ukraine throughout the year, including in-field verification activities, in accordance with Ukraine’s comprehensive safeguards agreement and additional protocol. On the basis of the evaluation of all safeguards relevant information available to the Agency, the Agency did not find any indication giving rise to a proliferation concern.



#### Pillar 1 – Physical integrity

The physical integrity of facilities — whether it is the reactors, fuel ponds or radioactive waste stores — must be maintained.



#### Pillar 2 – Safety and security systems and equipment

All safety and security systems and equipment must be fully functional at all times.



#### Pillar 3 – Operating staff

The operating staff must be able to fulfil their safety and security duties and have the capacity to make decisions free of undue pressure.



#### Pillar 4 – Off-site power supply

There must be a secure off-site power supply from the grid for all nuclear sites.



#### Pillar 5 – Logistical supply chain

There must be uninterrupted logistical supply chains and transportation to and from the sites.



#### Pillar 6 – Radiation monitoring and emergency preparedness and response

There must be effective on-site and off-site radiation monitoring systems, and emergency preparedness and response measures.



#### Pillar 7 – Communication

There must be reliable communication with the regulator and others.

*The seven indispensable pillars for ensuring nuclear safety and security during an armed conflict.*

## Agency Missions to Ukraine



*The Director General meeting Ukrainian staff at South Ukraine NPP, 29 March 2022.*



*The Director General meeting Ukrainian officials during his visit to the Chornobyl Exclusion Zone, 26 April 2022.*



*The Director General, accompanied by IAEA nuclear safety, security, and safeguards staff, setting off on their first visit to ZNPP, 29 August 2022.*





The Director General meeting with Ukraine's President Volodymyr Zelenskyy in Kyiv during the IAEA Support and Assistance Mission to Zaporizhzhya, 30 August 2022. (Photograph courtesy of the Ukrainian Presidential Press Service)



The Agency's ISAMZ arrives at ZNPP, 1 September 2022.

## First International Conference on Nuclear Law: The Global Debate

The Agency held its First International Conference on Nuclear Law: The Global Debate from 25 to 29 April 2022 at Headquarters in Vienna. The conference provided a unique forum for leading global experts from governments, international and non-governmental organizations, industry, academia and civil society to discuss and share experiences of topical issues in international and national nuclear law, and emerging issues and trends regarding current and evolving peaceful applications of nuclear science and technology, with a view to identifying areas for possible further development. The conference also provided an opportunity to discuss capacity-building programmes in this field and opportunities and challenges for the next generation of nuclear lawyers. In addition, it enabled an examination of the role of nuclear law in the context of other areas of law, including energy law, environmental law, maritime law and the law of the sea. Held in a hybrid format, with both in-person and virtual participation, the event was attended by a total of 1124 people from 127 Member States and 31 organizations.

In preparation for the conference, the Agency published a book entitled *Nuclear Law: The Global Debate*, available in Arabic, Chinese, English, French, Russian and Spanish. On the sidelines of the conference, the Director General launched a partnership initiative with six academic institutions in Africa, the Americas and the Middle East to increase educational and professional development opportunities for students and aspiring professionals in the field of nuclear law.



Opening plenary session of the conference, on “Nuclear Law: The Vision”, April 2022.

## NUCLEAR TECHNOLOGY

### Nuclear Power, Fuel Cycle and Nuclear Science

#### Status and trends

For a second successive year, the Agency revised up its annual projections of the potential growth of nuclear power during the coming decades, reflecting a shift in the global debate around energy and the climate amid growing concerns over energy security.

In its new outlook for global nuclear capacity for electricity generation, the Agency increased its high case projection to 873 gigawatts (electrical) (GW(e)) in 2050. To be realized, this would require large scale implementation of long term operation (LTO) across the existing fleet and nearly 600 GW(e) of new build in the coming three decades.

At the end of 2022, the world's total nuclear power capacity was 393.8 GW(e), provided by 438 nuclear power reactors in operation in 32 countries. During the year, over 7.4 GW(e) of new capacity was connected to the grid, from 6 pressurized water reactors; 3.3 GW(e) of capacity was retired, with the permanent shutdown of 5 nuclear power reactors. Supplying 2486.8 terawatt-hours of greenhouse gas emission-free electricity, nuclear power accounted for approximately 10% of total global electricity generation and more than a quarter of the world's low carbon electricity production. At the end of the year, 59.3 GW(e) of capacity was under construction, comprising 58 reactors, including 8 reactors (9.1 GW(e)) where construction started in 2022.

#### International conferences

The International Ministerial Conference on Nuclear Power in the 21st Century provided a forum for high-level talks involving around 800 participants from 69 countries and 9 international organizations. The participants agreed that nuclear power can make a significant impact on the decarbonization of the power sector, which is a necessary condition to reach net zero, in line with the Paris Agreement.

The Fifth International Conference on Nuclear Power Plant Life Management gathered 540 participants from 61 Member States and 8 international organizations who exchanged information on programmes for safe and reliable operation, ageing management, modernization and innovation to ensure a sustained contribution to climate change and energy security objectives.



*The Director General together with Jennifer Granholm, US Secretary of Energy, opening the International Ministerial Conference on Nuclear Power in the 21st Century, Washington DC, October 2022.*

The International Conference on Fast Reactors and Related Fuel Cycles: Sustainable Clean Energy for the Future brought together about 680 participants from 52 Member States and 3 international organizations who discussed national and international programmes for the deployment of fast reactors, their fuels and fuel cycles.

The Agency's first International Conference on Accelerators for Research and Sustainable Development: From Good Practices Towards Socioeconomic Impact enabled some 400 participants from 71 Member States and 3 international organizations to share the latest advances concerning the use of different particle accelerators for cutting edge research and various applications.



*The Director General opens the first International Conference on Accelerators for Research and Sustainable Development, May 2022.*



*Conference participants visit the Vienna Environmental Research Accelerator facility at the University of Vienna optimized for accelerator mass spectrometry.*

### **Energy assessment services**

The Agency continued to assist Member States in energy planning to address sustainable development and climate change mitigation. At 51 events, specialists from Africa, Asia, Europe, and Latin America and the Caribbean learned how to evaluate their energy needs, including by using the Agency's energy assessment tools.

The Agency signed a memorandum of understanding with the Latin American Energy Organization on cooperation in the area of energy. The Agency also took part in COP27 held in Sharm el-Sheikh, Egypt.

The publication *Economic Evaluation of Alternative Nuclear Energy Systems: Supplement for the INPRO ASENES Service* (IAEA-TECDOC-2014) assists Member States in conducting economic evaluations of nuclear energy system alternatives and explains the limits of the models used for these evaluations.

### **Digital innovation and artificial intelligence for nuclear power**

The Agency launched a working group focusing on the deployment of AI solutions for nuclear power plants (NPPs) to share knowledge and experience and to address related challenges. A meeting bringing together representatives of regulators, operators, national laboratories, technical organizations and academia initiated the development of a new publication entitled *Deployment of Artificial Intelligence Solutions for the Nuclear Power Industry: Considerations and Guidance*.

The Agency launched a global initiative to support nuclear decommissioning that will collect experiences of the practical application of, and case studies on, new and emerging tools and technologies, such as AI, automation and digitalization, used in data management, planning, licensing and implementation of decommissioning.

### **Support for operating nuclear power plants**

The Agency launched an international network on NPP life management. The network's five working groups focused on good practices and lessons learned, activities during the pre-operational phase of new nuclear power projects, risk-informed decision making, the need to adapt to climate change, and equipment reliability during beyond design basis accidents, all in the context of extended plant operation.

An online training course on Nuclear Supply Chain Management and Procurement was released for the first time in a recorded format, ensuring continuous availability. It provides information about good practices for managing procurement and supply chain activities related to the construction, operation and maintenance of NPPs.

### **Launching nuclear power programmes**

The Agency continued its assistance to newcomer countries. It conducted a Phase 1 Integrated Nuclear Infrastructure Review (INIR) mission to Sri Lanka, and delivered the final Phase 1 INIR report to Uganda (see related case study).

### ***Economics and financing of nuclear power projects***

Meeting the goals of the Paris Agreement will require a substantial increase in the level of investment in clean energy technologies. Increased recognition of nuclear energy's climate credentials may open up sustainable financing options that are already accessible to other low carbon technologies. The Agency organized 12 workshops on nuclear financing and on the macroeconomic impacts of investments in the nuclear sector, providing awareness of existing financing approaches.

### ***Capacity building, knowledge management and nuclear information***

Six Nuclear Energy Management (NEM) Schools (Canada, China, Italy, Japan, Russian Federation and South Africa) and four Nuclear Knowledge Management Schools (Chile, Italy, Russian Federation and USA) were conducted. Owing to ongoing COVID-19 restrictions, the annual Abdus Salam International Centre for Theoretical Physics (ICTP) NEM School and the China-IAEA NEM School were hosted virtually.

The Agency conducted 14 Knowledge Management Assist Visits, to Chile, Ethiopia, Indonesia, Jordan, Mauritius, Mexico, Nigeria, Rwanda, South Africa, Syrian Arab Republic, and two each to Kenya and Tunisia, reviewing their knowledge management programmes and providing recommendations for enhancements.

Over the year, 124 854 new records were added to the International Nuclear Information System (INIS), including 14 180 full-text documents. The INIS repository was accessed by over 2 million users, who viewed over 4.7 million pages and performed nearly 3 million unique searches.

The Agency officially launched the IAEA Preprint Repository, providing users with Agency publications in advance of their final editing and approval. As of the end of 2022, over 100 preprints had been made available.

### ***Stakeholder engagement***

The Technical Meeting on Stakeholder Involvement and Public Communication and the Technical Meeting for Municipalities with Nuclear Facilities provided a forum for information exchange on current programmes and for interaction between different stakeholders. The meetings served to highlight capacity-building needs in stakeholder engagement.

### ***Assurance of supply***

The IAEA Low Enriched Uranium Bank in Kazakhstan, which became operational in 2019, continued safe operations at the Ulba Metallurgical Plant.

A low enriched uranium reserve in Angarsk, established following the agreement of February 2011 between the Government of the Russian Federation and the Agency, remained operational.

## Fuel cycle

The Agency conducted a Uranium Production Site Appraisal Team (UPSAT) mission to review Mongolia's uranium exploration and mining regulations and the Badrakh in situ recovery pilot test project.



UPSAT review mission coordinated by the Agency in Mongolia, May 2022.

## Reactor technology development, innovation and preparation for deployment

The Agency held a Regional Workshop on Advances in the Modelling and Simulation of Thermal Hydraulics in Liquid Metal Cooled Fast Reactors in India and a joint ICTP–IAEA Workshop on Physics and Technology of Innovative Nuclear Energy Systems.

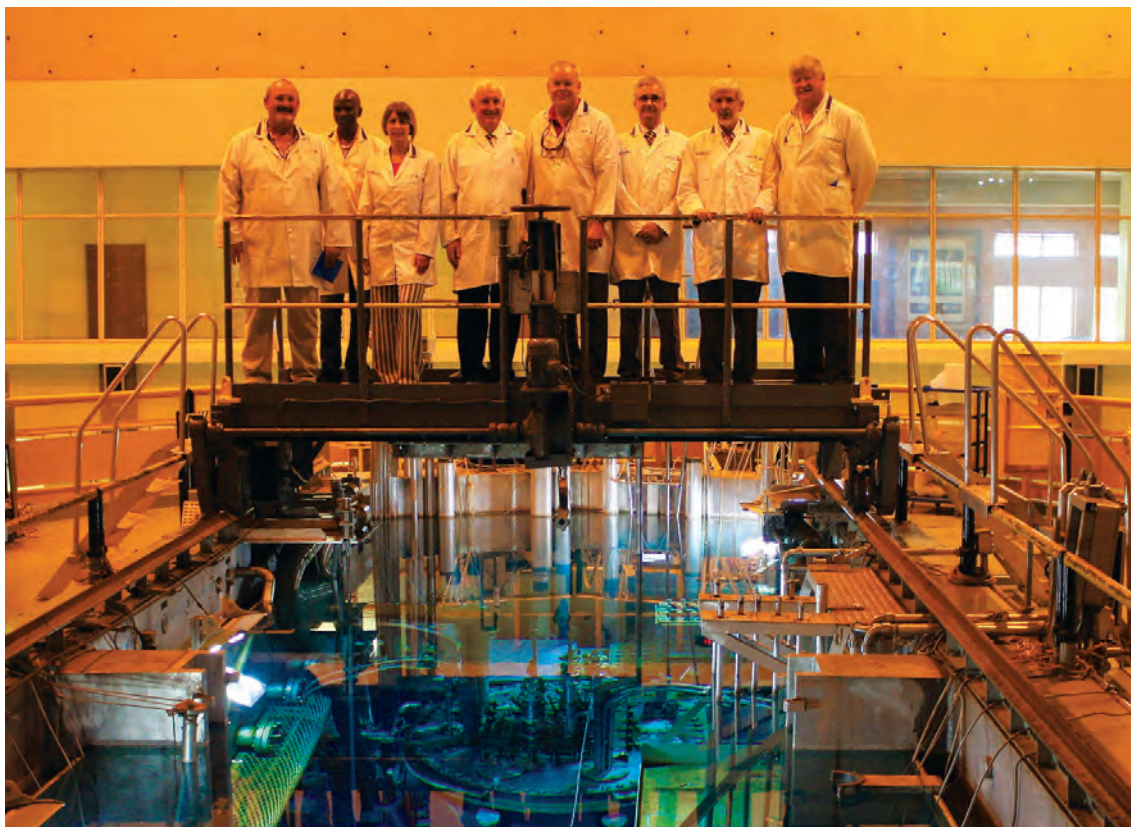
The Agency published the 2022 edition of *Advances in Small Modular Reactor Technology Developments* — a supplement to its Advanced Reactors Information System — which provides an overview of existing small and medium sized or modular reactor (SMR) designs.

## Research reactors

Two new training services were introduced. The pilot National Workshop on the Use of Decision Support Tools in Research Reactor Spent Fuel Management, held in Malaysia, supported the development of recommendations concerning the disposition of spent research reactor fuel. The pilot National Training Course on Human Resource Development Plan assisted in planning human resources for Senegal's research reactor programme.

The Integrated Nuclear Infrastructure Review for Research Reactors (INIR-RR) follow-up mission in Nigeria reviewed the development of national nuclear infrastructure for the planned multipurpose research reactor.

The Agency piloted its Integrated Research Reactor Utilization Review (IRRUR) by conducting three missions, to Chile, Peru and South Africa, and provided recommendations for improving and expanding the utilization of research reactors in these countries.



*Agency and Necsa teams taking part in the IRRUR mission at the SAFARI-1 research reactor, November 2022. (Photograph courtesy of Necsa)*

### **Radioactive waste management**

The Agency launched the Disused Sealed Radioactive Sources Technical Centre peer review to scale up support for the safe and secure management of such sources.

The Agency published the second edition of *Status and Trends in Spent Fuel and Radioactive Waste Management* (IAEA Nuclear Energy Series No. NW-T-1.14 (Rev.1)), which provides a global overview of the status of radioactive waste and spent fuel management concerning inventories, programmes, current practices, technologies and trends.

### **Decommissioning and environmental remediation**

The Agency conducted a peer review requested by the Indonesian National Research and Innovation Agency (BRIN) on the programme for decommissioning and storage of radioactive waste and spent fuel, and provided BRIN with an independent review of back end activities of three research reactors in Indonesia.

The Joint ICTP–IAEA International School on the Physical Basis for Radionuclide Migration trained participants on how to approach contaminated site assessment to support further decision making regarding storage, disposal and other practices.

The Agency published *Management of Naturally Occurring Radioactive Material (NORM) in Industry: Proceedings of an International Conference, Vienna, Austria, 18–30 October 2020*, summarizing discussions at the conference.



## Nuclear fusion

The Agency and the US Department of Energy's Princeton Plasma Physics Laboratory signed Practical Arrangements to strengthen education, training and outreach programmes in nuclear fusion research internationally.

The Agency published *World Survey of Fusion Devices 2022*, which provides a worldwide survey of over 130 public and private fusion devices with experimental and demonstration designs currently in operation, under construction, or planned.

The Agency initiated a new INPRO collaborative project to investigate legal and institutional issues of the prospective deployment of fusion facilities.

## Nuclear data

The Agency signed Practical Arrangements with the China Nuclear Data Center in Beijing with a focus on new web technology for efficient nuclear data retrieval and machine learning methods applied to nuclear reaction and nuclear structure physics.

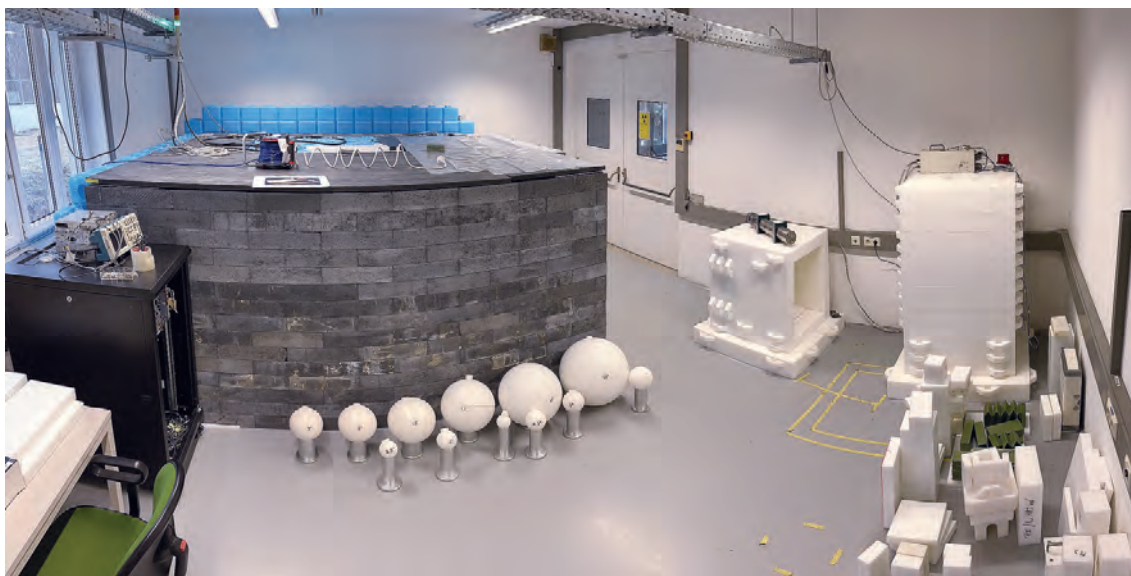
## Accelerator technology and its applications

Japan's Okayama University was designated as an IAEA Collaborating Centre in the area of boron neutron capture therapy, a non-invasive therapeutic technique for treating invasive malignant tumours.

The Agency continued its endeavours under the 'Atoms for Heritage' initiative by organizing advanced training courses and workshops, where some 200 participants from 63 Member States enhanced their knowledge about advances in accelerator technology concerning analysis and characterization of heritage objects.

## Nuclear instrumentation

After successful completion of its commissioning phases, the Agency's Neutron Science Facility delivered its first hands-on training on operation and applications of neutron generators.



*After full commissioning of the Agency's Neutron Science Facility, shielding structures housing deuterium–deuterium (right) and deuterium–tritium (left) neutron generators were employed to deliver the first two-week hands-on training course on neutron science and applications.*

## The Agency at COP27

Led by the Director General, the Agency's prominent presence at COP27 in Sharm el-Sheikh, Egypt, helped to ensure high visibility for nuclear power, science and technology at the world's main climate change conference. In cooperation with international partners, the Agency for the first time hosted a nuclear-themed pavilion at a COP, the '#Atoms4Climate' pavilion, offering numerous stakeholders a venue to showcase the role of nuclear power, science and technology in climate change mitigation, adaptation and monitoring.

Over the two weeks, the #Atoms4Climate pavilion hosted 44 events, including 20 Agency-led events, the highest number of nuclear events at a COP. These brought together governments, associations, civil society, academia and the media to discuss the nexus between nuclear and climate change, including the contribution of nuclear power to climate-resilient energy systems, the role of nuclear power alongside renewables in reaching net zero, the financing of clean energy transitions, nuclear technologies for climate monitoring and adaptation in mountains, climate-smart agriculture, and the management of marine ecosystems and sustainable water resources.

At a United Nations Framework Convention on Climate Change side event jointly organized by the Agency, the United Nations Economic Commission for Europe (UNECE) and the United Nations Industrial Development Organization (UNIDO), IAEA Director General Rafael Mariano Grossi, UNECE Executive Secretary Olga Algayerova and UNIDO Director General Gerd Müller elaborated the benefits and challenges of deploying resilient low carbon technology and highlighted the importance of synergies between low carbon technologies to collectively address climate crises and facilitate the net zero transition. The Agency and FAO jointly organized an event in the FAO pavilion on the nexus of food, energy and water, and best practices for integrating closely interlinked global resource systems and value chains to mitigate the impact of climate change. The Agency presented its Energy Compact, submitted for the SDG 7-related High-level Dialogue on Energy, in the SDG pavilion. The Agency also organized or participated in a number of events at the French, Science, Water and other pavilions.

The Director General launched the Atoms4NetZero initiative at COP27. It aims to model the potential contribution of nuclear energy to the pathway to net zero. Through this initiative, the Agency will support its Member States and other stakeholders, such as industry, financial institutions and other international organizations, by providing scientific and engineering evidence on the potential of



*The IAEA Director General with the UNECE Executive Secretary and the UNIDO Director General during the COP27 side event on the “Interplay of Low Carbon Technologies for Resilient Net Zero Energy Systems”, November 2022.*

nuclear technologies to help decarbonize not only the power sector, but also hard-to-abate sectors in industry and transport.

The Agency implemented an effective communication strategy and conducted impactful outreach and engagement with different stakeholders including policymakers, international organizations, civil society, and youth and women’s groups, to highlight the indispensable role of nuclear at the climate debate table. The #Atoms4Climate logo and hashtag were prominent in media coverage.



*The IAEA Director General engages with Maria Helena Semedo, FAO Deputy Director-General; Petteri Taalas, Secretary-General of the World Meteorological Organization; Juergen Voegelé, Vice President of the World Bank; and Anil Mishra of UNESCO at the “Science for the Future” high-level event at the #Atoms4Climate pavilion, November 2022.*



*The Agency’s #Atoms4Climate pavilion at COP27 in Sharm el-Sheikh, Egypt, November 2022.*

## Nuclear Sciences and Applications

### *International Symposium on Managing Land and Water for Climate-Smart Agriculture*



*The Director General at the opening of the International Symposium on Managing Land and Water for Climate-Smart Agriculture, July 2022.*

The International Symposium on Managing Land and Water for Climate-Smart Agriculture, jointly organized by the Agency and FAO, was held in hybrid format in Vienna in July 2022. The symposium facilitated the exchange of scientific information among soil, water and environment experts and aimed to increase understanding, collaboration, networking and capabilities in order to enhance food security, improve the conservation of natural resources and mitigate the negative impacts of climate change. The symposium also identified knowledge gaps, research needs and new opportunities to develop climate-smart agricultural practices.

### *Second International Conference on Applications of Radiation Science and Technology*

The Second International Conference on Applications of Radiation Science and Technology (ICARST-2022) was held in hybrid format in Vienna in August 2022 to showcase key developments in radiation science and technology applications, including the production of advanced high-performance materials; green technologies to rehabilitate the environment; new trends in food irradiation; studies on the stability and compatibility of irradiated products in the human body; and novel approaches to managing radiotracers and other related nuclear techniques. It also served as a platform for industry and academia to foster new initiatives in this field.



*Opening of ICARST-2022, August 2022.*

### ***International Conference on Integrated Medical Imaging in Cardiovascular Diseases***

The Agency held the International Conference on Integrated Medical Imaging in Cardiovascular Diseases (IMIC-2022) to review the status of evidence-based recommendations on the use of various imaging modalities, including single photon emission computed tomography, positron emission tomography, echocardiography, computed tomography and magnetic resonance imaging, in the management of cardiovascular diseases. The event brought together top scientists and practitioners, who showcased the latest developments in cardiac imaging.

### ***ReNuAL2***



*Groundbreaking ceremony for the new laboratories building in Seibersdorf, 5 October 2022.*

Key milestones were reached under the final phase of the Renovation of the Nuclear Applications Laboratories (ReNuAL) initiative, known as ReNuAL2. In October 2022, ground was broken for the construction of a new building to house the Nuclear Science and Instrumentation Laboratory, the Terrestrial Environmental Radiochemistry Laboratory and the Plant Breeding and Genetics Laboratory. Major construction is expected to be completed by the end of 2024. Under ReNuAL2, the project team mobilized more than €22 million of extrabudgetary contributions from 29 Member States and non-traditional donors. Resource mobilization efforts are currently focused on raising €3.4 million required by early 2023 for new greenhouses.

### **Artificial intelligence for nuclear science, technology and applications**

The Agency publication *Artificial Intelligence for Accelerating Nuclear Applications, Science and Technology* provides a review of current AI activities in the nuclear field, highlights the Agency's role in their implementation, outlines challenges and identifies priorities for future AI activities. In 2022, the Agency continued working with the High-Level Committee on Programmes' Inter-Agency Working Group on Artificial Intelligence on the adoption of principles for the ethical use of AI in the UN system. It also continued its partnership with the "AI for Good" platform and contributed to the 2022 report *United Nations Activities on Artificial Intelligence (AI)*, which featured new Agency AI initiatives in the areas of radiotherapy, the marine environment, radioactive contamination in agriculture, climate change impact assessment and fusion science. All these activities were integrated in "AI for Atoms", a new Agency knowledge-sharing platform for partnership on AI applications in the nuclear field.

## **Food and Agriculture**

### **Memorandum of Understanding between the Agency and FAO**

In October 2022, the Agency and FAO signed a memorandum of understanding (MOU) to leverage innovative research and development activities using the comparative advantage presented by nuclear and related technologies to transform agrifood systems. The MOU expands the scope of cooperation to the marine environment, physical and chemical sciences and human health and supports a stronger strategic partnership through joint resource mobilization and the implementation of programmatic and advocacy activities.



*FAO Director-General, Qu Dongyu, and IAEA Director General, Rafael Mariano Grossi, sign an MOU to strengthen cooperation between FAO and the Agency, October 2022.*

### Seeds in space

Given the growing interest in understanding how the space environment could produce mutations in plant genomes and modify plant physiology, the Agency and FAO, through the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture, initiated a feasibility study to determine whether the harsh environment of outer space would trigger mutations in plant seeds that would allow them to boost their tolerance to increasingly difficult growth environments created by climate change. Seeds were sent to space in November 2022, to be returned to Earth after 3–4 months.

### Antimicrobial resistance

Agricultural systems are increasingly polluted by antimicrobial substances, including antibiotics, which are used to prevent and treat infections. In 2022, the Agency developed techniques to monitor the pathway of sulfamethoxazole, an antibiotic commonly used in veterinary medicine, in soil carbon turnover processes. Results have shown a strong reduction in the mineralization of organic matter and accelerated priming, leading to losses in soil carbon. In addition, the Agency developed soil and water sampling and analytical protocols, harmonized techniques for diagnostics and monitoring of synthetic labelled antibiotics in field-applied manure, and published a technical paper in cooperation with FAO entitled *Antimicrobial movement from agricultural areas to the environment: The missing link. A role for nuclear techniques*.

### Irradiated vaccines



Agency research scientist using an X-ray machine to irradiate larger organisms at lower doses.

To effectively control zoonotic diseases, better vaccines — and better access to those vaccines — are required. The Agency has conducted research on the use of irradiation to develop new vaccine formulations. This novel approach aims to inhibit the replication capacity of pathogens while maintaining their metabolic activities, and to reduce antigen alterations using radioprotectors. Under the ZODIAC project, the Veterinary Diagnostic Laboratory Network has developed techniques to produce irradiated vaccines for priority animal and zoonotic diseases.

### **Food safety and authenticity**

Food safety is compromised by foodborne contaminants, diseases and events that disrupt normal food production and control systems, such as extreme weather, the COVID-19 pandemic or food fraud. In 2022, the Agency helped Member States protect consumers and industry from the impacts of food fraud by developing nuclear analytical and fingerprinting methodologies to facilitate the rapid and cost-effective testing of commodities in the field. These techniques can detect contaminants, provide information on the geographical origin of products and help verify claims of organic fruit and spice production.



*Sample preparation to verify the geographical origin and detect the adulteration of honey by measuring the ratio of stable isotopes of hydrogen ( $\delta^2\text{H}$ ) in honey saccharides.*

## **Human Health**

### **Launch of a global database on breast milk intake**

In 2022, the Agency launched its database on human milk intake, which provides the most comprehensive picture to date on breast milk intake around the globe. The database constitutes a growing collection of studies that use the deuterium oxide dose-to-mother nuclear technique to determine how much breast milk is consumed by breastfed infants. By combining data from individual studies, the database generates new value and helps to answer globally relevant questions on breast milk intake, exclusive breastfeeding, and infant feeding patterns more generally.



### ***Release of Audit Methodology for Medical Physics Clinical Training Programme***

Clinically qualified medical physicists contribute directly to ensuring the safety, quality and effectiveness of patient diagnosis and treatment, and structured and supervised clinical training programmes equip medical physicists with the competencies needed in the clinical environment. To develop and provide national training programmes, the Agency published the *Audit Methodology for Medical Physics Clinical Training Programmes* (IAEA-TCS-74), which provides guidance on how to establish and sustain such programmes.

### ***New services at the Agency's Dosimetry Laboratory***

The Agency contributes actively to the harmonization of dosimetry worldwide. In 2022, electron beam audit, photon calibration and high dose rate brachytherapy source calibration services were launched to enhance Member States' capacity to implement radiation imaging and treatment modalities safely and effectively, using optimized dosimetry and medical physics practices. In addition, the Agency's Dosimetry Laboratory commissioned a gamma beam irradiator, which is providing reference data that increases the accuracy of radiation protection level dosimetry for Agency staff.

## **Water Resources**

### ***Addressing the water crisis***

In 2022, the Agency actively promoted the value of nuclear and isotopic techniques in global water-related activities, including preparatory meetings for the 2023 UN Water Conference, the World Water Forum, the Second Dushanbe Water Action Decade Conference, World Water Week, COP27 and the UN-Water Summit on Groundwater. It also strengthened its relationships with other international organizations, including the World Bank Group, the World Meteorological Organization and the United Nations Educational, Scientific and Cultural Organization, with which the Agency is currently embarking on a capacity-building initiative to address global water resource monitoring and assessment.

### ***Launch of new isoscape model***

The Global Network of Isotopes in Precipitation (GNIP) is being increasingly used by Member States to track changes in precipitation and as a baseline for assessing groundwater resources. Building on GNIP data, the Agency published a revised and updated Regionalized Cluster-Based Water Isotope Prediction Model of isoscapes for naturally occurring tritium in precipitation. The resulting maps depict the spatial distribution of present-day tritium in precipitation and aid understanding of the connection between the atmosphere, surface water and groundwater systems. In addition, the Agency's Tritium Intercomparison (TRIC) exercise in 2022 yielded a record number of 93 submissions.

## Marine Environment

### *Using radionuclides to assess the potential of blue carbon as a nature-based solution to climate change worldwide*

Blue carbon, which refers to carbon sequestered in vegetated marine and coastal ecosystems with the aim of reducing atmospheric carbon dioxide, is a key focus for the IAEA Marine Environment Laboratories. The Agency implements several joint projects with international research institutions in 30 countries, using radionuclides to assess the rates of carbon sequestration in vegetated marine and coastal areas as well as to evaluate the capacity of these ecosystems as long-term carbon storage solutions.

### *Emergency response support to Peru to assess the impact of a major oil spill on the marine environment*

In January 2022, rogue waves hit an unloading oil tanker at La Pampilla refinery in Peru. Approximately 10 000 barrels of crude oil leaked into the sea. At the request of the Government of Peru, the Agency rapidly mobilized its experts to support the country. Through coordinated efforts with the national environmental authorities and a UN mission team, technical advice was provided, a long-term monitoring strategy was devised and work was initiated on the collection and preservation of oil and environmental samples for follow-up analysis.

### *Plastic-derived contaminants and their impact on the marine environment*

Plastic-derived chemical contaminants are an emerging threat to ocean health, in particular sensitive marine ecosystems. The Agency develops analytical methods that target chemicals linked to plastics, using stable isotopes and mass spectrometric techniques to accurately measure toxic contaminants in the marine environment at ultra-trace levels. In 2022, these methods were used in collaboration with the Scientific Centre of Monaco and provided valuable insights into the combined effects of exposure to chemicals linked to plastic debris and ocean warming, highlighting the potential threat of plastic pollution to sensitive ecosystems.



*Agency research scientist conducts laboratory experiment on tropical coral nubbins.*

## Radiochemistry and Radiation Technology

### *Accreditation as reference material producer*

In 2022, the Agency's Marine Environmental Studies Laboratory and Terrestrial Environmental Radiochemistry Laboratory obtained accreditation as producers of reference materials for gamma-emitting radionuclides in marine and terrestrial environmental matrices. To date, four materials have obtained certified reference material status within the scope of the accreditation.

### *Launch of new IAEA/WHO guideline*

Mindful of the rapid expansion of molecular imaging and targeted radiopharmaceutical therapy, the Agency and WHO launched a new guideline on good manufacturing practices for investigational radiopharmaceutical products. The guideline is in line with trends in good manufacturing practices specific to investigational radiopharmaceuticals used in clinical trials and is harmonized with other related international guidelines.

### *Quality assurance for analysis of environmental samples*

As a developer and custodian of reference materials for stable isotope scales worldwide, the Agency organized its first ever training course on enhancing the quality of data for isotopic analysis in Member State laboratories to present the best approaches for calibrating relevant instruments and calculating data for stable isotope analysis of environmental and food samples.

## NUCLEAR SAFETY AND SECURITY

### Nuclear and Radiation Safety

#### *Safety standards and their application*

The Agency issued 17 Safety Guides after their endorsement by the Commission on Safety Standards. The Agency launched an e-learning course on the safety standards, in Arabic, Chinese, English, French, Russian and Spanish.

The Agency conducted 62 safety- and security-related peer review and advisory service missions to support 46 Member States in the application of safety standards and nuclear security guidance publications.

#### *International conferences*

The Agency organized the International Conference on Occupational Radiation Protection: Strengthening Radiation Protection of Workers – Twenty Years of Progress and the Way Forward in Geneva, Switzerland, in September 2022. The conference identified emerging issues in occupational radiation protection and discussed implementation of safety standards concerning occupational radiation protection; commitment to safety culture; and exchange of operating experience. A 'call for action' document was drafted as an outcome of the conference.

The Agency held the International Conference on Topical Issues in Nuclear Installation Safety: Strengthening Safety of Evolutionary and Innovative Reactor Designs in Vienna in October 2022, where recommendations were issued in the areas of robust safety demonstration; harmonization



*International Conference on Occupational Radiation Protection: Strengthening Radiation Protection of Workers – Twenty Years of Progress and the Way Forward, held in Geneva, Switzerland, September 2022.*

and standardization; international collaboration; experimental data and tools; and integrated use of deterministic and probabilistic considerations for evolutionary and innovative reactors.

The Agency held the International Conference on the Safety and Security of Radioactive Sources: Accomplishments and Future Endeavours in Vienna in June 2022. The conference discussed experiences and anticipated future developments related to establishing and maintaining a high level of safety and security of radioactive sources throughout their life cycle.

### ***Advanced Liquid Processing System treated water***

The Agency made substantial progress in 2022 in its review of safety-related aspects of the handling of Advanced Liquid Processing System (ALPS) treated water at Fukushima Daiichi NPP. The ALPS task force conducted three technical review missions and the Agency published three reports throughout the year. Additionally, the task force conducted seven meetings, including a meeting that focused on the Agency's laboratory capabilities and the initiation of the Agency's independent sampling and analysis work associated with the planned water discharges. The Agency facilitated four sampling campaigns for ALPS treated water and one sampling campaign for environmental samples (seawater, seaweed, etc.), with analysis of these samples scheduled to begin in 2023.



Agency expert processing ALPS treated water samples taken at Fukushima Daiichi NPP for further analysis by Agency and third-party laboratories. (Photograph courtesy of TEPCO)

### **Safety of nuclear power plants, research reactors and fuel cycle facilities**

In March, the Agency conducted its 50th Safety Aspects of Long Term Operation mission, at Koeberg NPP in South Africa.

The Agency held the Fifth International Conference on Nuclear Power Plant Life Management in Vienna in November–December 2022. The conference provided an international forum for presentations of key elements of plant life management programmes and safety aspects of LTO, such as: ageing management strategies; preparation and implementation of LTO projects, including material testing, prediction models and risk informed models; supply chain; knowledge management; and regulatory approaches to LTO activities. This diverse event brought together participants from all countries operating NPPs and several international organizations and featured the active engagement of regulators, operators and technical support and research organizations.

### **Safe and secure deployment of advanced reactors, including SMRs**

The Agency conducted the first mission related to the siting of SMRs, examining the site selection process for an SMR in Romania, in August 2022. Feedback from the mission was utilized to develop a Site and External Events Design review module tailored to SMR-type reactors, with particular emphasis on the application of a graded approach to siting and design.

### **Assisting countries embarking on a new nuclear power programme**

The Agency held a meeting of the Regulatory Cooperation Forum (RCF) Steering Committee in Vienna in June 2022 to review the status of regulatory infrastructure development in countries receiving support from the RCF and to foster the exchange of experience. In addition, regular RCF task team meetings were held to monitor and evaluate the implementation of the RCF Strategic Plan and related activities.

## Incident and emergency preparedness and response



*The Director General delivers his opening remarks at the Eleventh Meeting of the Representatives of Competent Authorities identified under the Early Notification Convention and the Assistance Convention held at Agency Headquarters in Vienna, June 2022.*

In June 2022, the Agency held the Eleventh Meeting of the Representatives of Competent Authorities identified under the Early Notification Convention and the Assistance Convention to share information on national emergency preparedness and response (EPR) arrangements and related challenges.

The Agency maintained continuous communication with the Ukrainian nuclear regulatory authority, the State Nuclear Regulatory Inspectorate of Ukraine, from 24 February 2022 and conducted daily assessments of the situation at Zaporizhzhya NPP (ZNPP) from 2 September 2022 and assessments of the situation at other NPPs and nuclear facilities, based on the information received from the IAEA Support and Assistance Mission to Zaporizhzhya NPP and other monitoring activities and missions undertaken.

### **Radioactive waste management, environmental assessments and decommissioning of nuclear facilities**

The Agency developed guidance on the conduct of Integrated Regulatory Review Service (IRRS) and Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) missions in a back-to-back manner. This guidance was used for the first time in Slovenia, where an IRRS mission held in April 2022 was followed by an ARTEMIS mission in May 2022.

The Agency held a Technical Meeting on Methods for Radiological and Environmental Impact Assessment (MEREIA) in November 2022 and a series of webinars on MEREIA focusing specifically on development of young professionals.

### ***Radiation protection***

The Agency, in association with the Radiation Protection Symposium North-West Europe, organized the Tenth International Symposium on Naturally Occurring Radioactive Material in Utrecht, Netherlands, in May 2022, to provide a forum for the industrial, technical and scientific communities and regulatory bodies involved in the management of naturally occurring radioactive material (NORM) and to disseminate scientific information, research and knowledge with a focus on the use of residues from industrial operations and processes involving NORM.

In 2022, the Agency made available technical guidance jointly sponsored by FAO and WHO on how to manage exposures due to radionuclides in food in non-emergency situations.

### ***Capacity building in nuclear, radiation, transport and waste safety and emergency preparedness and response***

The Agency conducted 168 capacity-building activities on nuclear, radiation, transport and waste safety and EPR, including training courses, fellowships, workshops, webinars and the launch of e-learning packages.

The Agency, in cooperation with Tokai University, Japan, held the first virtual International School on Nuclear and Radiological Leadership for Safety. Three more Schools were organized in Egypt, Mexico and Pakistan during 2022.

In July 2022, on the occasion of the 25th anniversary of the Ibero-American Forum of Radiological and Nuclear Regulatory Agencies (FORO), celebrated in Madrid, the Portuguese Environment Agency joined FORO, becoming its 11th member.

### ***Safety conventions***

The Agency facilitated the Fourth Extraordinary Meeting of the Contracting Parties to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention) in Vienna in May 2022, and the Seventh Review Meeting of the Joint Convention in Vienna in June–July 2022.

The Agency continued preparations for the Joint Eighth and Ninth Review Meeting of the Contracting Parties to the Convention on Nuclear Safety, to be held in March 2023.

### ***Codes of conduct***

In 2022, the number of States having notified the Agency of their intention to act in accordance with the Code of Conduct on the Safety and Security of Radioactive Sources grew to 145. The number of States having notified the Agency of their intention to act in accordance with the Guidance on the Import and Export of Radioactive Sources increased to 129, and the number of States having notified the Agency of their commitment to implement the Guidance on the Management of Disused Radioactive Sources rose to 52 in 2022.

The Agency continued to assist Member States in the application of the Code of Conduct on the Safety of Research Reactors. The Agency also provided assistance through peer reviews and advisory services and capacity-building activities on areas of the Code identified from Member States' self-assessments as needing improvement.



*Opening of the Seventh Review Meeting of the Contracting Parties to the Joint Convention, June 2022.*

### ***The Agency's Radiation Safety and Nuclear Security Regulator***

The Agency's Radiation Safety and Nuclear Security Regulator approved the design of the new Flexible Modular Laboratory 2 at Seibersdorf, a modification to the Neutron Science Facility, clearance of material from the Nuclear Material Laboratory, and the radiation protection programmes for several Agency Departments. The operation authorization for the Dosimetry Laboratory was modified to permit the use of a new irradiator. Inspections were conducted at the Nuclear Science and Instrumentation Laboratory and the Nuclear Security Detection and Monitoring Equipment Laboratory.

### ***Civil liability for nuclear damage***

The Agency acted as the Secretariat of the Second Meeting of the Contracting Parties and Signatories to the Convention on Supplementary Compensation for Nuclear Damage (CSC), which was held in Vienna in May–June 2022.

The International Expert Group on Nuclear Liability (INLEX) held its 22nd regular meeting in September. The Group discussed, *inter alia*, liability issues concerning insurance of radioactive sources, right of recourse of nuclear fusion facilities operators, small modular reactors, nuclear powered ships, and supplementary compensation obligations for parties to both the Brussels Supplementary Convention and the CSC. The Group also adopted a statement on the “Benefits of Joining the Global Nuclear Liability Regime”. The meeting was followed by a half-day Workshop for Diplomats on Civil Liability for Nuclear Damage.

During the 66th regular session of the General Conference, the Agency hosted a special side event to celebrate the 25th anniversary of the CSC and the 1997 Vienna Convention on Civil Liability for Nuclear Damage. In the context of the Agency's Legislative Assistance Programme, support was provided to Member States in the development of national legislation, including legislation related to civil liability for nuclear damage. In addition, the Secretariat also conducted several joint legislative assistance–INLEX missions to address the importance of establishing a



global regime, including two sub-regional workshops on nuclear law for Asia and the Pacific and a bilateral mission to Saudi Arabia.

### ***Interfaces between safety and security***

In 2022, the Regulatory Infrastructure Development Projects assisted participating countries in the Latin America and the Caribbean and Africa regions to enhance their regulatory framework for radiation safety and security of radioactive material in the areas of policy and strategy, regulations, establishment of an integrated management system, national inventory and registry, and physical protection of radioactive sources.

The Agency issued *Regulatory Oversight of the Interfaces Between Nuclear Safety and Nuclear Security in Nuclear Power Plants* (Technical Reports Series No. 1003) as a preprint document.

In 2022, the Agency hosted regular meetings of the International Nuclear Safety Advisory Group (INSAG) to discuss current and emerging safety issues and identify needs for new INSAG publications. The Agency's Advisory Group on Nuclear Security and INSAG worked on a report entitled *A Systems View of Nuclear Security and Nuclear Safety – Identifying Interfaces and Building Synergies*.

## **Nuclear Security**

### ***Conference of the Parties to the Amendment to the Convention on the Physical Protection of Nuclear Material***

The Agency organized the Conference of the Parties to the Amendment to the Convention on the Physical Protection of Nuclear Material, pursuant to Article 16.1 of the Convention as amended, in Vienna in March–April 2022. The conference reviewed the implementation of the Convention as amended and its adequacy as concerns the preamble, the whole of the operative part and the annexes in the light of the then prevailing situation.

### ***Capacity building and outreach in nuclear security***

In 2022, the Agency provided assistance in drafting nuclear security regulations to 53 Member States. It also conducted 140 training events for more than 4000 participants from 154 States and continued to deliver its e-learning activities, with over 2500 users from 140 States completing e-learning modules during the year. Two new e-learning modules were developed and two e-learning modules were translated from English and made available in Arabic, Chinese, French, Russian and Spanish during the reporting period. In total, there are 21 e-learning modules, 19 of which are available in Arabic, Chinese, English, French, Russian and Spanish.

### ***Supporting Member States' needs***

Targeted assistance is provided to States, upon request, to address needs identified within the Integrated Nuclear Security Support Plan (INSSP) framework and in line with Member State priorities. In 2022, the total number of States with approved INSSPs remained at 92. As of 31 December 2022, there were 16 INSSPs awaiting Member State acceptance and 5 INSSPs were at the initial drafting stage.

The Agency's programme to support States' major public events provided assistance throughout the year ranging from large sporting events to major international conferences and international cultural and religious occasions.

The Agency continued to construct the Nuclear Security Training and Demonstration Centre at its Seibersdorf laboratories. This specialized facility is scheduled to be operational at the end of 2023 and will provide support to States through state-of-the-art technical infrastructure and equipment.



*INSSP finalization mission to Bolivia, July 2022.*

## NUCLEAR VERIFICATION<sup>1,2</sup>

Over the course of 2022, the impact of the COVID-19 pandemic on safeguards implementation diminished markedly. The Agency carried out 3000 verification activities (3000 in 2021) and spent 14 100 days in the field conducting those activities (14 600 in 2021). This ensured that the Agency was able to draw soundly based conclusions for all States in which safeguards were implemented by the Agency for 2022.

### *Implementation of safeguards in 2022*

At the end of every year, the Agency draws a safeguards conclusion for each State for which safeguards are applied. This conclusion is based on an evaluation of all safeguards relevant information available to the Agency in exercising its rights and fulfilling its safeguards obligations for that year.<sup>3</sup>

<sup>1</sup> The designations employed and the presentation of material in this section, including the numbers cited, do not imply the expression of any opinion whatsoever on the part of the Agency or its Member States concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

<sup>2</sup> The referenced number of States Parties to the Treaty on the Non-Proliferation of Nuclear Weapons is based on the number of instruments of ratification, accession or succession that have been deposited.

<sup>3</sup> For States with a comprehensive safeguards agreement (CSA) in force with an operative small quantities protocol (SQP) based on the original standard text, the Agency's ability to draw a credible and soundly-based annual safeguards conclusion is significantly affected. This is due, inter alia, to the fact that the original standard text of the SQP holds in abeyance the requirement for these States to provide to the Agency an initial report on all nuclear material as well as the Agency's right to perform verification activities in these States. In light of such limitations, and given the significant lapse of time since the decision of the Board of Governors in 2005 authorizing the Director General to conclude with each State with an SQP an exchange of letters giving effect to the revised standardized text and the modified criteria, the Agency may no longer be able to draw a safeguards conclusion for such States unless the States concerned respond positively to the repeated calls by the Director General to amend or rescind such SQPs.

In 2022, safeguards were applied for 188 States<sup>4,5</sup> with safeguards agreements in force with the Agency. Of the 134 States that had both a comprehensive safeguards agreement (CSA) and an additional protocol (AP) in force, the Agency drew the broader conclusion that *all* nuclear material remained in peaceful activities for 74 States<sup>6</sup>; for the remaining 60 States, as the necessary evaluation regarding the absence of undeclared nuclear material and activities for each of these States remained ongoing, the Agency concluded only that *declared* nuclear material remained in peaceful activities. Similarly, for the 46 States with a CSA but with no AP in force, the Agency concluded only that *declared* nuclear material remained in peaceful activities.

Safeguards were also implemented with regard to nuclear material in selected facilities in the five nuclear-weapon States Parties to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) under their respective voluntary offer agreements. For these five States, the Agency concluded that nuclear material in the selected facilities to which safeguards had been applied remained in peaceful activities or had been withdrawn from safeguards as provided for in the agreements. For three States not party to the NPT, the Agency implemented safeguards pursuant to item-specific safeguards agreements based on INFCIRC/66/Rev.2. For these States, the Agency concluded that nuclear material, facilities or other items to which safeguards had been applied remained in peaceful activities.

As of 31 December 2022, five States Parties to the NPT had yet to bring CSAs into force pursuant to Article III of the Treaty. For these States Parties, the Agency could not draw any safeguards conclusions.

### ***Conclusion of safeguards agreements and APs, and amendment and rescission of small quantities protocols***

The Agency continued to facilitate the conclusion of safeguards agreements and APs, and the amendment or rescission of small quantities protocols (SQPs). The status of safeguards agreements and APs as of 31 December 2022 is shown in Table A6 in the Annex to this report. During 2022, a CSA with an SQP and an AP entered into force for Cabo Verde and Guinea-Bissau. A CSA with an SQP entered into force for the State of Palestine<sup>7</sup>. An AP was signed for Sierra Leone. SQPs were amended for the Lao People's Democratic Republic, Namibia, Suriname and Tuvalu. An SQP was rescinded for Lithuania. At the end of 2022, 99 States with CSAs in force had operative SQPs, of which 77 SQPs were based on the revised standard text, and 11 States had rescinded their SQPs.

### ***Verification and monitoring in the Islamic Republic of Iran in light of United Nations Security Council resolution 2231 (2015)***

Between 16 January 2016 and 23 February 2021, the Agency, in light of UN Security Council resolution 2231 (2015), verified and monitored the Islamic Republic of Iran's (Iran's) implementation of its nuclear-related commitments under the Joint Comprehensive Plan of Action (JCPOA). From 8 May 2019 onwards, however, Iran reduced the implementation of those commitments on a step-by-step basis and, from 23 February 2021 onwards, stopped the implementation of those commitments, including the AP. This seriously affected the Agency's verification and monitoring in relation to the JCPOA, which was exacerbated in June 2022 by Iran's decision to remove all of the Agency's equipment previously installed in Iran for surveillance and monitoring activities in relation to the

<sup>4</sup> These States do not include the Democratic People's Republic of Korea (DPRK), where the Agency did not implement safeguards and, therefore, could not draw any conclusion.

<sup>5</sup> And Taiwan, China.

<sup>6</sup> And Taiwan, China.

<sup>7</sup> The designation employed does not imply the expression of any opinion whatsoever concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

JCPOA. During 2022, the Director General submitted to the Board of Governors, and in parallel to the UN Security Council, 4 quarterly reports and 15 reports providing updates on developments between the issuance of the quarterly reports, entitled *Verification and monitoring in the Islamic Republic of Iran in light of United Nations Security Council resolution 2231 (2015)*.

### **Islamic Republic of Iran**

During 2022, despite the Agency's continued efforts to engage Iran in order to resolve outstanding safeguards issues related to the presence of uranium particles of anthropogenic origin at locations in Iran not declared to the Agency, limited progress was made. Unless and until Iran clarifies these issues, the Agency will not be able to provide assurance about the exclusively peaceful nature of Iran's nuclear programme. The Director General submitted four reports to the Board of Governors entitled *NPT Safeguards Agreement with the Islamic Republic of Iran*. The Board of Governors adopted by a vote two resolutions entitled *NPT Safeguards Agreement with the Islamic Republic of Iran*.

### **Syrian Arab Republic**

The Director General continued to urge the Syrian Arab Republic to cooperate fully with the Agency in connection with all unresolved issues. In August 2022, the Director General submitted a report to the Board of Governors entitled *Implementation of the NPT Safeguards Agreement in the Syrian Arab Republic*.

### **Democratic People's Republic of Korea**

In September 2022, the Director General submitted a report to the Board of Governors and the General Conference entitled *Application of Safeguards in the Democratic People's Republic of Korea*. In 2022, no verification activities were implemented in the field, but the Agency continued to monitor developments in the nuclear programme of the Democratic People's Republic of Korea (DPRK) and to evaluate all safeguards relevant information available to it. The Agency did not have access to the Yongbyon site or to other locations in the DPRK. The continuation of the DPRK's nuclear programme, a clear violation of relevant UN Security Council resolutions, is deeply regrettable.

### **State-level safeguards implementation**

The Agency continued to enhance the consistency and effectiveness of safeguards implementation through a project aimed at improving the development and implementation of State-level approaches (SLAs) using a structured approach. Performance targets were embedded in a new dedicated IT application in 2022 to support acquisition path analysis and the development of SLAs. This application simplified the process and facilitated the updating of SLAs for 16 States with the broader conclusion during the year. These SLAs will be implemented in 2023.

### **Naval nuclear propulsion**

The use of nuclear material subject to safeguards under a CSA by a State in a nuclear activity such as naval nuclear propulsion is foreseen by the CSA. Australia and Brazil have informed the Agency of their plans related to the use of nuclear material — subject to safeguards under their respective CSA — for naval nuclear propulsion. The use of nuclear material in such an activity requires arrangements under their respective safeguards agreements and the development of appropriate Agency safeguards approaches. Hence, during 2022, the Secretariat engaged in consultations with the States concerned to consider the possible implications on the application of Agency safeguards.

### ***Cooperation with State and regional authorities***

In 2022, the Agency conducted over 50 training events for personnel responsible for overseeing and implementing State systems of accounting for and control of nuclear material (SSACs) and regional systems of accounting for and control of nuclear material. These events were a combination of in-person and virtual training courses, as well as scientific visits. In total, more than 450 experts from 70 States were trained on safeguards-related topics. During the year, 11 Member States contributed in-kind support to the implementation of 18 activities as part of the IAEA Comprehensive Capacity-Building Initiative for SSACs and SRAs, including scientific visits, expert visits, SSAC webinars, and the development of safeguards procedures and national training plans.

### ***Safeguards equipment and tools***

In 2022, the active universal asymmetric seal was authorized for use. It will start to be deployed in 2023 to replace the electronic optical sealing system, providing the Agency with an optimized life cycle cost. The laser curtain for containment, which uses lasers to detect possible intrusion in a safeguarded area in a nuclear facility, was used for the first time in 2022. A new high-resolution cadmium zinc telluride detector was validated by Agency technical experts. Its integration into various non-destructive assay systems will support the standardization of parts and reduce the need for specific training for inspectors.

### ***Safeguards analytical services***

As of December 2022, the Agency's Network of Analytical Laboratories (NWAL) consisted of the Agency's Safeguards Analytical Laboratories and 25 other qualified laboratories in various Member States. During the year, six additional laboratories for sample analysis and reference material provision were in the process of qualification. In 2022, the Agency collected 604 nuclear material samples, 516 environmental samples and 5 heavy water samples that were analysed by the Agency's laboratories in Seibersdorf and through the NWAL.

### ***Developing the safeguards workforce***

In 2022, the Agency conducted 45 distinct safeguards staff training courses (as some were held more than once, a total of 92 offerings were provided overall, of which 26 were held outside Vienna), helping to provide safeguards inspectors, analysts and support staff with the necessary core and functional competencies. The Safeguards Traineeship Programme for young graduates and junior professionals commenced in February 2022, involving nine participants (including five women) from Algeria, Cameroon, Costa Rica, Guyana, Nigeria, Panama, Tajikistan, the United Republic of Tanzania and Yemen.

### ***Partnerships***

The Agency forged new partnerships in support of Agency safeguards during the course of the year. In 2022, the United Arab Emirates declared its intention to establish a new Member State Support Programme and provided a significant financial contribution to the Department of Safeguards for initial activities. To further broaden the support base for Agency safeguards, the Agency also signed Practical Arrangements with the Open Nuclear Network and the Henry L. Stimson Center.

### ***Safeguards Symposium***

In 2022, the Agency organized its 14th Symposium on International Safeguards with the theme 'Reflecting on the Past and Anticipating the Future'. The programme featured 70 different sessions,



*The Director General signs the AP for Sierra Leone and receives a copy of its SQP amendment letter at a special event on the safeguards legal framework, October 2022.*

over 150 presentations, 24 exhibitors and 3 experiential rooms devoted to different futures. Some 700 registered participants — of whom 36% were women — from 124 States and 15 organizations attended the event. The Symposium's programme, video recordings, papers, e-posters and more are available on its website.

## MANAGEMENT OF TECHNICAL COOPERATION FOR DEVELOPMENT

### The Technical Cooperation Programme in 2022

In 2022, the Agency provided assistance to 149 countries and territories through the TC programme, including key support for activities related to ZODIAC, NUTEC Plastics and Rays of Hope, in the form of training, expert advice and equipment procurement.

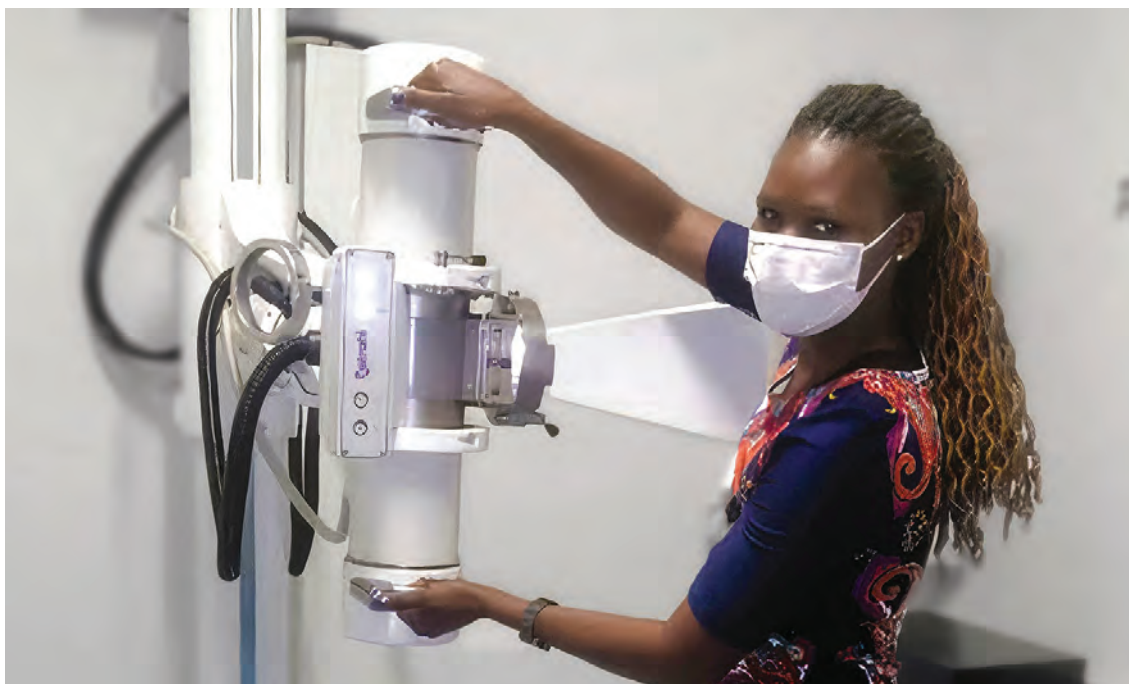
Member States interested in small modular reactors were supported through an interregional project involving 46 countries and 12 participating donors. In 2022, activities included a training course on establishing a national position for a new nuclear power programme, held in St Petersburg, Russian Federation.

In 2022, food and agriculture accounted for the highest proportion of actuals (disbursements) delivered through the programme, at 26.7%. This was followed by health and nutrition at 21.6% and by safety and security at 16.7%. By the end of the year, financial implementation of the Technical Cooperation Fund (TCF) stood at 84.4%.

Nineteen Country Programme Frameworks (CPFs) — for Belarus, Botswana, Côte d'Ivoire, the Dominican Republic, Estonia, Fiji, Guatemala, Jordan, Malaysia, Mongolia, Montenegro, Nepal, Papua New Guinea, the Philippines, Qatar, Rwanda, Saint Lucia, Viet Nam and Zimbabwe — were signed in 2022, bringing the total number of valid CPFs to 112 by the end of the year.

## Overview of Regional Activities

### Africa



*A new orthovoltage radiotherapy machine installed at Windhoek Central Hospital treated skin cancer patients for the first time in 2022. (Photograph courtesy of Dr AB May Cancer Care Centre)*

In 2022, the Agency provided technical cooperation to 46 Member States in Africa, including 26 least developed countries (LDCs). Approximately 80% of this assistance was delivered in the areas of food and agriculture, human health and nutrition, radiation safety and human resource development. This is in line with the region's priority areas, as outlined in the CPFs of individual Member States and the African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA) Regional Strategic Cooperative Framework for 2019–2023. Important assistance in the form of training and laboratory equipment was provided under ZODIAC for the early monitoring of zoonotic diseases.

Twenty-five Member States in the region requested participation in Rays of Hope. Bilateral meetings were held with the Ministers of Health of 15 Member States to identify needs and assess the financial resources required to assist them in establishing or expanding their countries' radiotherapy services.

In May, an orthovoltage radiotherapy machine for treating skin cancer, purchased with government cost-sharing contributions, treated its first patients in Windhoek. In July, a new brachytherapy unit began providing treatment to cervical cancer patients in Madagascar.

Djibouti opened its Regional Research Observatory on the Environment and Climate, established with Agency assistance to study the impact of climate change.

The first sterile insect technique release trial in South Africa, targeting malaria mosquitoes, was carried out in northern KwaZulu-Natal from May to December, with 30 000 sterile males released each week. Preliminary results indicate a 60–70% decline in the fecundity of the wild mosquito population.

In March, a PhD conference on water resources management, the first to be held within the framework of a TC project, took place in Vienna. Fifteen sandwich PhD fellows and one postdoctoral fellow presented their work.

Ministers and permanent secretaries from seven African Member States interested in establishing research reactors met in August to learn about the Agency's Milestones approach and requirements for the establishment of such facilities.

The Congo received Agency assistance in February to remove two disused cobalt-60 sealed radiotherapy sources from the country.

### Asia and the Pacific



*The Director General at the opening of the RCA exhibition at the 66th regular session of the General Conference, September 2022.*

Thirty-nine Member States and territories in Asia and the Pacific receive technical cooperation, of which seven are LDCs and seven are small island developing States (SIDS). In 2022, approximately 60% of technical cooperation in the region addressed food and agriculture, health and nutrition, industrial applications and radiation safety, with the remainder focusing on nuclear energy, the environment and nuclear knowledge management, in line with the priorities set out in Country and Regional Programme Frameworks.

Four pilot countries in Asia made progress in developing irradiation technology for use in plastic recycling under NUTEC Plastics and are now prioritizing the establishment of industrial partnerships. National stakeholder meetings were held in Indonesia and Malaysia to engage government representatives and potential industrial partners.

A two-week virtual lecture series on SDGs in the South Pacific, aimed at university teaching staff and postgraduate research students from faculties covering science and related fields, was launched in partnership with the Australian Nuclear Science and Technology Organisation and the University of the South Pacific. The lectures were attended by some 300 participants, both online and in person.

Twenty-five universities and institutions attended the first annual meeting of the International Nuclear Science and Technology Academy, which focused on the expansion of nuclear science and technology education at the tertiary level.



## Europe



*Agency staff visit Dashoguz oncology hospital in Turkmenistan and assess radiation medicine capacity.*

In 2022, the TC programme provided assistance to 33 Member States in Europe and Central Asia. A focus was placed on enhancing nuclear and radiation safety, the diagnosis of non-communicable diseases, cancer treatment and radiation medicine. During the 66th regular session of the General Conference, Member States endorsed a new regional profile for Europe and Central Asia (2022–2027).

Turkmenistan's first national TC programme began in 2022. Activities focused on cancer diagnosis and treatment, radiation safety and regulatory infrastructure, and radioactive waste management.

The Board of Governors approved an off-cycle TC project to help Ukraine strengthen radiation therapy and medical imaging. The project will provide equipment and strengthen human resource capabilities to ensure increased access to, and effective delivery of, cancer diagnosis, management and treatment, and will be implemented and delivered through existing Agency mechanisms, under the Rays of Hope initiative. The project aims to strengthen existing services to meet increasing demand, in particular at some medical institutions that have become key locations for cancer patients coming from different parts of the country.

## Latin America and the Caribbean

In 2022, the Agency provided technical assistance to 31 Member States in Latin America and the Caribbean, focusing on human health, food and agriculture, radiation safety, and water and the environment.

In February, 12 scientists from Latin America received training at the Agency's Seibersdorf laboratories in crop mutation breeding for resistance to Fusarium wilt, which affects critical banana plantations in the region. Sixteen national reference laboratories received equipment and training to improve their early detection capacities.

The Research Network of Marine-Coastal Stressors in Latin America and the Caribbean established harmonized strategies for the sampling and analysis of microplastics to ensure the collection of comparable data. The goal is to establish a regional database on the quantity of microplastics in marine and coastal environments.



*Andrew Holness, Prime Minister of Jamaica, at the inauguration of Jamaica's first public nuclear medicine centre, June 2022.*

The regional chapter of Women in Nuclear (WiN) for Latin America and the Caribbean continued to support equal female participation in nuclear science and technology. In September, it launched a guide on gender mainstreaming in the nuclear sector in the region entitled 'Somos Potencia' (We Are the Power).



*The Director General at the opening of the WiN booth at the 66th regular session of the General Conference, September 2022.*

## Emergency Response

The TC programme is flexible and agile, and can respond quickly to the urgent needs of Member States. In 2022, following historic flooding in Pakistan, the Agency and FAO consulted closely with Pakistan's Government and national agriculture and veterinarian institutes to develop an emergency support package to assist the country in applying nuclear science to better understand the impact of the flood on soils and crops, as well as the potential spread of animal and zoonotic diseases.

An expert mission to Cyprus in May under a project to develop a rapid response strategy to prevent the establishment of the Asian tiger mosquito discovered the presence of the *Aedes aegypti* mosquito, which is the primary vector for diseases such as dengue, Zika and chikungunya and poses a potential threat to the country's healthcare system and its important tourism industry. In response to this finding and following a request from the Member State, the Agency developed an emergency response plan. The Asian tiger mosquito was subsequently found on the island later in the year and the ongoing project was adjusted to help Cyprus address this emergency.

Following a large fire at Cuba's Matanzas supertanker base in August, the Agency procured environmental and air quality monitoring equipment to support local efforts to measure the effect of the fire and develop mitigation strategies. Furthermore, to aid the country's recovery efforts in the wake of Hurricane Ian, the Agency procured mobile X-ray equipment for four hospitals and equipment to determine environmental contaminants and water quality.

Following an oil spill off the coast of Callao, Peru in January, the Agency rapidly responded to assess the environmental situation and organized the necessary assistance upon the request of the country.

A computed tomography scanner was delivered to Saint Vincent and the Grenadines to replace the only such scanner in the country, damaged during the eruption of the La Soufrière volcano.

Mexico received Agency support following a fruit fly outbreak in Colima in 2021. An emergency action plan based on integrated pest management, including the application of the sterile insect technique, was implemented in 2021 and 2022 to control the outbreak (see related case study).

## Programme of Action for Cancer Therapy (PACT)

Through the WHO-IAEA Joint Programme on Cancer Control, the Agency supported Member States by assessing their cancer control capacities, providing expert advisory support for the development of national cancer control programmes (NCCPs) and strategic documents, and mobilizing resources.

Support for Member States under Rays of Hope is coordinated across the Agency and has been initiated in seven African countries: Benin, Chad, the Democratic Republic of the Congo, Kenya, Malawi, the Niger and Senegal. Regional anchor centres will provide regional training and expertise. The pool of both traditional and non-traditional partners has already expanded and efforts are under way to match partners to Member States in need. The Agency has established partnerships with international financial institutions such as the Islamic Development Bank, and helps Member States develop bankable documents to apply for concessional loans. Through such triangular cooperation and the Rays of Hope initiative, more financial resources will be invested from international financial institutions to support the use of radiation medicine to treat cancer in developing countries.

ImPACT Review missions were conducted in Colombia, the Lao People's Democratic Republic, the Syrian Arab Republic and Uzbekistan, with in-country follow-up missions carried out in the Syrian Arab Republic and Uzbekistan and virtual follow-ups carried out for Costa Rica and El Salvador. Reviews were also initiated in Cambodia, El Salvador, Fiji, Jordan and the Sudan. The Agency provided technical advice for NCCP elaboration to ten countries — Benin, Botswana, Burundi, Kenya, Paraguay, Senegal, Sierra Leone, the Sudan, Zambia and Zimbabwe — and conducted in-country workshops in nine of these countries. Burundi, the Central African Republic, the Democratic



The *imPACT* Review team visits the Farah Children's Cancer Association in Lattakia, Syrian Arab Republic, October 2022.

Republic of the Congo, Togo, the United Republic of Tanzania and Zambia were assisted in drawing up bankable documents. The *Methodology for Integrated Missions of the Programme of Action for Cancer Therapy (imPACT Reviews)* (IAEA Services Series No. 46) was published, along with a peer reviewed article on its evolution.

## Technical Cooperation and the Global Development Context

In February, the Agency participated in the fifth session of the United Nations Environment Assembly and a special session of the United Nations Environment Assembly (UNEP@50), highlighting the contribution of nuclear and nuclear-related technologies to addressing plastic pollution, zoonotic diseases, water and groundwater management, ocean acidification, agriculture and coastal agriculture, ecosystems restoration and energy transition.

In May, the Agency participated in person at the 75th World Health Assembly. The Director General reaffirmed the Agency's continued close cooperation with WHO on cancer, nutrition and zoonotic diseases.

In July, the Agency participated in the United Nations High-level Political Forum on Sustainable Development, presenting its contributions to the achievement of SDGs such as quality education, life below water and life on land. It highlighted the contribution of nuclear science and technology to sustainable development and presented the support it provided to SIDS. At a side event on desertification and land degradation, the Agency presented the role of nuclear techniques in soil and water management and in supporting recovery. It also participated in a side event hosted by Namibia and South Africa on gender in science, technology and innovation.

In August, Agency representatives participated in the 72nd Session of the WHO Regional Committee for Africa, in Lomé, meeting more than 20 Ministers of Health. It also took part in the WHO Regional Committee for Europe, held in Israel, and explored regional cooperation on cancer.

In September, the Agency attended the United Nations Global South–South Development Expo to raise awareness of the contribution of nuclear technology to sustainable development in the context of South–South and triangular cooperation, and to identify new partnership and resource

mobilization opportunities. It supported a side event on harnessing the power of the atom, and two exhibition booths.

In October, the Agency participated in the Asian Development Bank's Innovation Fair, where it showcased the socioeconomic impact of nuclear technology in agriculture, health and industry.

Also in October, the Agency attended the World Cancer Congress 2022, where a focus was placed on the need to forge new, and expand traditional, partnerships in the global fight against cancer.

At the invitation of the Indonesian G-20 President, the Agency participated in the G-20 Research and Innovation Initiative Gathering and Research and Innovation Ministers' Meeting, where it underscored the importance of nuclear science and technology in relation to health, plastic pollution, energy and food security.

## Legislative Assistance

Country-specific bilateral legislative assistance was provided to seven Member States through written comments and advice on drafting national nuclear legislation and six dedicated bilateral review meetings to provide specific advice on draft and enacted nuclear legislation. Three regional and sub-regional workshops were held for Member States in Asia and the Pacific, Latin America and the Caribbean and the Middle East. In addition, a further 18 legislative assistance activities were conducted, including 10 awareness-raising meetings and 8 national workshops on nuclear law.

The Agency organized the tenth session of the Nuclear Law Institute (NLI) in Vienna, Austria. The NLI is an interregional training event designed to give participants a solid understanding of all aspects of nuclear law, with a particular focus on legislative drafting. In addition, five webinars were held in 2022 as part of the Agency's interactive webinar series on topical issues in nuclear law.

The Agency also delivered short introductory courses on nuclear law at Khalifa University of Science and Technology in the United Arab Emirates and the University of Buenos Aires in Argentina as part of the university partnership initiative launched at the First International Conference on Nuclear Law: The Global Debate.

## Technical Cooperation Programme Management

### *Quality assurance activities, reporting and monitoring*

In 2022, the Agency focused on knowledge management, organizational learning and training of TC programme stakeholders, with the aim of enhancing the efficiency, effectiveness and relevance of the support provided to Member States.

Training on the use of the logical framework approach in project design was provided upon request to national TC project counterparts during the design phase of the 2024–2025 TC programme. Online tutorials on the TC project document template, the logical framework approach and the TC project work plan and budget were posted on the Programme Cycle Management Framework IT platform.

Project Progress Assessment Reports for the 2021 reporting period were received for 844 TC projects — a submission rate of 83%.

One hundred and fifty-one recommendations from the Office of Internal Oversight Services have been addressed since 2019. All recommendations owned by TC and issued prior to 2021 have been closed.

## Financial resources

The TC programme is funded by contributions to the TCF, extrabudgetary contributions, government cost-sharing and contributions in kind. New resources reached €129.6 million in 2022, with approximately €93.7 million for the TCF (including assessed programme costs arrears, National Participation Costs (NPCs) and miscellaneous income), €35.6 million in extrabudgetary resources and about €0.3 million in in-kind contributions. The rate of attainment for the TCF stood at 97.5% on payments and 98.7% on pledges at the end of 2022. Payment of NPCs totalled €4.0 million.

## Actuals

In 2022, approximately €108.7 million was disbursed to 149 countries or territories, of which 35 were LDCs.

## MANAGEMENT ISSUES

### Managing for results

The Agency continued its efforts to strengthen its results based management throughout the programme cycle. To that end, the Agency formally added a section to its administrative framework outlining the results based approach, thereby strengthening its effective internalization throughout the Agency. This includes the integration of knowledge management coordination into the Agency's results based management framework, implemented at the Department level through the development of Departmental knowledge management action plans. The Agency's risk management system was revised to further strengthen the links between risk management, results based management and internal controls.

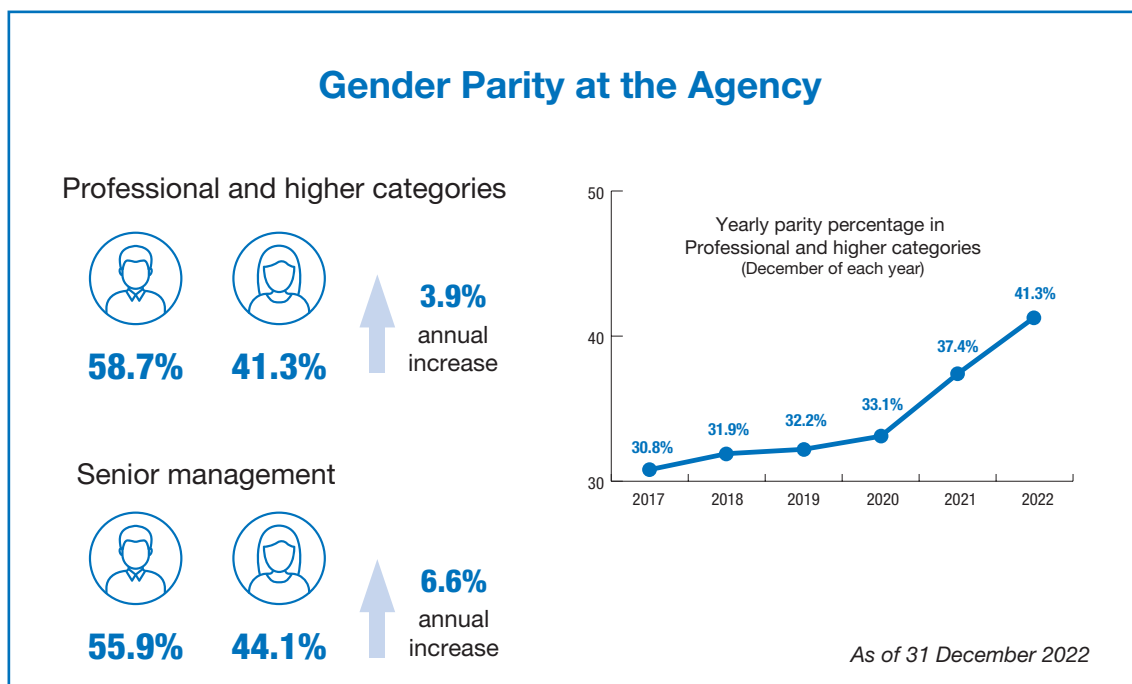
The Agency actively supported the update of UN system-wide guidance on results based management contained in the UN Development Group's *Results-based Management Handbook*, serving as informal guidance to Agency managers as well.

The Agency updated the Programme and Budget IT system with improved functionalities such as better assessment of actual achievements against planned targets during the reporting phase. In parallel, continuous capacity-building activities, particularly during the planning phase and as part of the induction programme for new managers, were developed and implemented.

### Gender equality and respect for diversity

Further to the goal set by the Director General, the Agency continued to strive to achieve gender parity in all levels of the Professional and higher categories by 2025. At the end of 2022, the percentage of women in the Professional and higher categories was 41.3%, the highest to date, and that of women in senior management positions (D level or higher) had reached 44.1%. These figures represent an increase of 3.9% and 6.6%, respectively, compared with the figures from December 2021. In 2022, the Secretariat continued to implement its Gender Equality Policy and its internal Gender Action Plan, which were updated in 2021 to include tasks for the 2021–2022 biennium.

In terms of programmatic gender mainstreaming, the focus continued to be on further mainstreaming a gender perspective into programme planning and implementation, reporting on gender-related programmatic results, and strengthening staff capacity for gender mainstreaming in programmes and activities. This included efforts to enhance the participation of women as training participants, fellows, scientific visitors, project counterparts, researchers, experts and panellists. With regard to planning for the 2024–2025 biennium, conducting a gender analysis was a mandatory requirement during project design. Similarly, every TC project design includes a section on cross-cutting issues,



including gender, where efforts to evaluate any different impacts on men and women are assessed and described. The Agency also assisted ARCAL in preparing and launching a practical guide on gender-related issues in nuclear in order to strengthen the capacities of national nuclear institutes by presenting potential strategies to promote gender mainstreaming at all levels.

In 2022, the Secretariat continued providing mandatory training in line with its Respect for Diversity and Anti-Discrimination Policy to promote a respectful workplace and discourage improper behaviour, and participated in training modules, jointly organized and delivered with other Vienna-based UN organizations, reaching over 700 staff members of the participating organizations.

The Secretariat also enhanced training for new and current managers to support them with leadership skills to manage their staff and processes in a diverse workforce.

### **Partnerships and resource mobilization**

Leveraging the Agency's approved projects distributed across the Departments, the Director General's initiatives are being implemented to step up the Agency's impact in addressing global challenges, including Rays of Hope, ZODIAC, NUTEC Plastics, NHSI, the IAEA Platform on Small Modular Reactors and their Applications, the Marie Skłodowska-Curie Fellowship Programme and the Lise Meitner Programme. They will continue to be implemented through enhanced in-house coordination and by mobilizing additional resources outside the Agency's traditional framework to bridge the gap between demand and resources. Similarly, coordination, cooperation and collaboration with other organizations in the UN system, other international organizations, governments and non-traditional partners — including development and regional banks, the private sector and foundations — will be further strengthened.

In 2022, the Agency received a total of €158 million in extrabudgetary contributions. At the same time, nearly 40 Practical Arrangements and 10 new memoranda of understanding were signed by the Agency.

Internally, the Director General adopted decisions for enhanced internal coordination, a more cohesive approach and increased accountability to deliver results with regard to mobilizing extrabudgetary resources. These decisions were implemented within existing resources and

organizational arrangements, focusing on three areas: a strengthened partnerships and resource mobilization (PRM) function in the Department of Technical Cooperation, the designation of dedicated Departmental PRM coordinators, and the revision and strengthening of the Partnerships and Resource Mobilization Coordination Committee's composition and function.

### **Information security and technology**

The Agency remained vigilant to ongoing cyberthreats as part of its regular IT operations and strengthened its information and IT security through a number of actions, including implementing a new information security management system, preparing for the ISO/IEC 27001 certification of the system managed by the Agency, increasing anti-malware and security defence mechanisms, and improving monitoring capabilities. In addition, the operational needs of the Agency in the context of the COVID-19 pandemic continued to be met, including supporting hybrid meetings, maintaining scalable remote access capabilities for staff, and adapting IT operating models as required.

### **Multilingualism**

The documents submitted to the Policy-Making Organs, and all Safety Requirements and editions of the IAEA Bulletin, were issued in Arabic, Chinese, English, French, Russian and Spanish. In addition, the translation of 59 publications from English into one or more other languages resulted in 98 issuances of publications in languages other than English. These included the translation of several publications in the IAEA Safety Standards Series, IAEA Nuclear Security Series, IAEA Nuclear Energy Series, and IAEA Technical Documents series, and of the *Nuclear Law: The Global Debate* book, into Arabic, Chinese, French, Russian and Spanish.

In 2022, the Agency continued offering regionally targeted (or 'localized') news on its web site (iaea.org) to better serve its audience in Arabic, Chinese, French, Russian and Spanish. By December 2022, the combined traffic in the languages other than English had increased by 23% compared to December 2021, accounting for 18% of the overall web traffic of iaea.org. This increase in traffic was also due to search engine optimization measures and to the Agency's regular reporting on the nuclear safety and security situation in Ukraine.

The Agency continued to regularly publish content on its Facebook accounts in Arabic, French, Russian and Spanish, and on its Weibo account in Chinese. Furthermore, the number of followers on the Agency's social media accounts in languages other than English grew by 11% during 2022. Other outreach activities included the production of 9 videos, 25 press releases and 34 interviews with the Director General, Deputy Directors General and Agency experts in languages other than English.





# **Nuclear Technology**

# Nuclear Power, Fuel Cycle and Nuclear Science



**1521**

online training and education courses hosted on **CLP4NET**



**24**

active coordinated research projects within the Department of Nuclear Energy



around  
**400**  
events



over **2 million**

International Nuclear Information System users  
nearly **3 million** unique searches  
over **4.7 million** page views



**24**  
databases

**25**  
modelling tools and simulators



**14**

active Collaborating Centres within the Department of Nuclear Energy

# 2022



## Internet Reactor Laboratory

**4** host institutions

**11** guest institutions



**31**

peer review missions



**6** IAEA-designated International Centres based on Research Reactors

in **6** countries



**29**

publications issued in 2022



## Participants in IAEA schools

**501** Nuclear Energy Management School

**392** Nuclear Knowledge Management School

**24** Regional Research Reactor School

# Nuclear Power

## Objective

*To support Member States with existing NPPs to enhance operating performance and safe, secure, efficient and reliable long term operation, with a harmonized approach to human, technological and organizational aspects. To support Member States embarking on new nuclear power programmes in planning and building their national nuclear infrastructures through coordinated assessment and assistance activities. To support Member States in modelling, analysing and assessing future NESs [nuclear energy systems] for sustainable development of nuclear energy and to provide them with collaborative frameworks and support for technology development and deployment of advanced nuclear reactors, non-electric applications, and integrated energy systems.*

## Launching Nuclear Power Programmes

In 2022, the number of Member States considering, planning or implementing a new nuclear power programme remained at 26. The Agency continued to provide support to them in building awareness of the commitments required for the decision making process and in developing the required infrastructure, in line with the Milestones approach.

Twelve Integrated Work Plan meetings were held to identify priority areas for Agency support for newcomer countries. The Agency conducted 13 training courses and workshops within the Integrated Nuclear Infrastructure Training programme and 21 workshops, consultancy meetings and expert missions in support of national nuclear power infrastructure development.



*Participants in the Interregional Training Course on Nuclear Power Infrastructure Development, held in November 2022 in Japan, during a visit to the Hamaoka NPP Training Centre.*

Together with the World Association of Nuclear Operators, the Agency hosted a side event on “Cooperation with Other International Organizations: Assistance to Embarking and Expanding Countries” during its 66th General Conference. The annual Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure continued to be a valuable forum for Member States to discuss challenges and issues in developing infrastructure for the introduction or expansion of nuclear power.

At the 13th meeting of the Technical Working Group on Nuclear Power Infrastructure, its members noted the significant growth in interest in nuclear power, the expectations from Member States, and the activities associated with new Agency initiatives, including the Nuclear Harmonization and Standardization Initiative and the IAEA Platform on Small Modular Reactors and their Applications.

The Agency signed a Memorandum of Understanding with the Arab Atomic Energy Agency to promote peaceful uses of nuclear energy and enhance nuclear power programme infrastructure, nuclear safety and security.

## Operating Nuclear Power Plants and Expanding Nuclear Power Programmes

The second Global Forum for Nuclear Innovation explored opportunities to accelerate innovation for the continued safe and reliable operation of the global fleet of operating nuclear power plants (NPPs).

The publication *Sustaining Operational Excellence at Nuclear Power Plants: Principles and Challenges* (IAEA Nuclear Energy Series No. NR-G-3.1) provides owners/operators with strategic responses to current business challenges and effective measures to sustain nuclear power’s uniquely high performance levels.

The publication *Management of Ageing and Obsolescence of Instrumentation and Control Systems and Equipment in Nuclear Power Plants and Related Facilities Through Modernization* (IAEA Nuclear Energy Series No. NR-T-3.34) assists Member States in developing strategies to address ageing and obsolescence issues for instrumentation and control systems, and conveys details and experience concerning modernization considerations.

The publication *Introduction to Systems Engineering for the Instrumentation and Control of Nuclear Facilities* (IAEA Nuclear Energy Series No. NR-T-2.14) assists Member States in understanding the philosophy and methodologies of systems engineering and provides guiding principles for its application to nuclear facility instrumentation and control.

## Human Resource Development and Management and Stakeholder Engagement Support

The publication *Human Resource Management for New Nuclear Power Programmes* (IAEA Nuclear Energy Series No. NG-T-3.10 (Rev. 1)) provides Member States with a structured approach to developing an effective human resource management strategy and the infrastructure needed to support the workforce across the key organizations in accordance with the nature and scope of a national programme.

The Agency modernized and updated the Nuclear Energy Capacity Building Hub site, hosted on the IAEA CONNECT platform, to provide Member States with online technical information to further sustain ongoing nuclear power projects.

Two workshops on human resources development for nuclear programmes, one held at the national level in Uzbekistan and the second at the interregional level in the Russian Federation, provided participants with an understanding of the levels of human resources and mix of competencies needed in the different phases of developing a nuclear power programme.

The workshop on the development of the technical support organization for Ghana’s nuclear power programme enabled participants to consolidate information on the establishment of external and internal technical support capability.

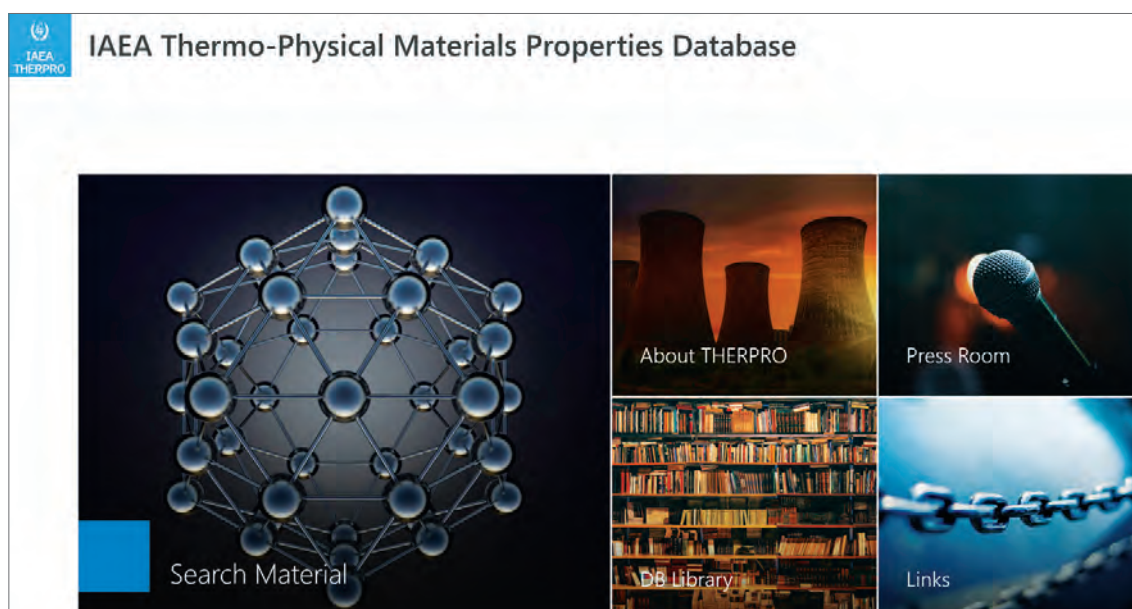
## Nuclear Reactor Technology Development

### *Technology development of advanced water cooled reactors*

A new coordinated research project (CRP) on Technical Evaluation and Optimization of Nuclear-Renewable Hybrid Energy Systems was launched to increase understanding of the role, performance and impact of these systems in meeting current and future energy demands.

The Agency launched a CRP on Advancing Thermal-Hydraulic Models and Predictive Tools for Design and Operation of SCWR Prototypes with the objective of establishing a coherent body of knowledge about fluids at supercritical pressures and/or temperatures needed to prototype supercritical water cooled reactor (SCWR) designs, and of closing gaps in technology areas relevant to design options.

The Agency modernized the Thermo-Physical Materials Properties Database (THERPRO), which provides information about various properties of materials found in the operating fleet of light and heavy water reactors and their advanced designs.



*The THERPRO database is an online comprehensive collection of thermo-physical material properties data. Data relating to more than 11 000 properties of about 1600 materials are compiled in THERPRO.*

The Agency launched a Simulation and Experimental Analyses Network Information System database, which gathers information about Member States' programmes and activities related to the analysis of severe accidents in nuclear reactors.

The Agency updated its publication *Nuclear Reactor Technology Assessment for Near Term Deployment* (IAEA Nuclear Energy Series No. NR-T-1.10 (Rev. 1)), which demonstrates how reactor technology assessment is performed and how it enables decision making in nuclear power planning.

New e-learning modules on advanced technologies and severe accidents were translated into several languages.

### ***Small and medium sized or modular reactors, including high temperature reactors***

A new CRP on Technologies Enhancing the Competitiveness and Early Deployment of Small Modular Reactors was launched to identify and enhance understanding of the families of enabling technologies with the potential to either reduce the construction cost and schedule or better suit users' needs, thus facilitating and favouring their early deployment.

## IAEA Platform on Small Modular Reactors and their Applications

Small modular reactors and their applications have the potential to make an important contribution to achieving global climate goals and energy supply security. There are more than 80 designs under development in 18 countries, according to the Advanced Reactors Information System.

The Agency supports Member States towards the safe and secure deployment of small modular reactors, which can enhance energy security while helping to achieve global climate goals. To this end, the Agency has launched two interconnected mechanisms: the IAEA Platform on Small Modular Reactors and their Applications and the Nuclear Harmonization and Standardization Initiative (NHSI).

Serving as the focal point for the Agency's activities in the field of small modular reactors and their applications, the Platform provides coordinated support and expertise from across the entire Agency, encompassing all aspects relevant to the development, deployment and oversight of small modular reactors. The Platform is designed to facilitate cooperation and collaboration among Member States and other stakeholders, supporting the safe and secure deployment of small modular reactors worldwide. It supports Member States in the early deployment of small modular reactors, including in accelerating their technology development and demonstration, enhancing their readiness level, and analysing the competitiveness of small modular reactors with respect to other clean energy technologies.

The medium-term strategy through 2029 for small modular reactors and their applications was developed to provide strategic direction and a road map for relevant activities. High-level work is under way to implement this strategy. The small modular reactors web portal has been established for sharing information on such reactors and their applications among all interested stakeholders and for coordinating all Agency activities in the areas of technology, safety, security and safeguards.

The Agency started providing assistance to the Brazilian Association for the Development of Nuclear Activities with regard to building an energy system model to evaluate the introduction of small modular reactors into electricity systems. A workshop on desalination was held and preparations started for an expert mission on using small modular reactors for electricity generation and nuclear desalination, for the Jordan Atomic Energy Commission (see related case study).



*The Director General visits CAREM-25, Argentina's first prototype small modular reactor, currently under construction, October 2022. (Photograph courtesy of I. Dambrauskas/CAREM)*

To address the growing interest in floating NPPs, the Agency started analysing potential issues in deploying this type of small modular reactor. A symposium on this topic is planned.

### ***Nuclear Harmonization and Standardization Initiative***

After the NHSI kick-off meeting (see p. 6 of the Overview chapter), the Agency invited industry representatives to send expressions of interest in participating in each of the four topical working groups in the industry track. Other industry stakeholders also joined subsequently. In addition, as three of the four topics had already been launched, Member States had had earlier opportunities to nominate representatives.

The groups made use of existing Agency mechanisms (consultancy or technical meetings, CRPs etc.), with nominated Technical Officers. Additional resources were sought via extrabudgetary contributions. Each topical working group had different schedules and activities in 2022, mainly focused on establishing and defining their scope and schedule.

The first working group is discussing the content of a high-level Agency publication that will harmonize existing user requirements as defined by three utility associations, and which is also intended to be a learning tool for non-nuclear utilities/users. The second working group's objective is to create a database enabling high-level comparisons in eight domains of codes and standards such as quality management, engineering and design (in collaboration with the World Nuclear Association's Cooperation in Reactor Design Evaluation and Licensing group), manufacturing, qualification, oversight and acceptance. The third group's focus is to establish global cooperation and resource-sharing for experiments and code validation between entities operating experimental facilities, technology holders and technical support organizations, in collaboration with the OECD/NEA. The fourth working group is working on developing a publication aimed at providing forward-looking scenarios that could accelerate the deployment of small and medium sized or modular reactors and microreactors in technology-recipient countries.

Two interface meetings took place involving industry representatives and the regulatory track to discuss and determine industry participation in the three working groups in the regulatory track.

Regular communication with external stakeholders from both tracks on progress under NHSI is planned through interface informational calls.

### ***Fast reactors***

Participants in the Technical Meeting on Open-source Tools supported a new project on Open-source Nuclear Codes for Reactor Analysis and the Agency conducted several workshops and webinars on neutronics codes, thermal hydraulics codes and system codes for reactor analysis.

The Technical Meeting on State-of-the-art Thermal Hydraulics of Fast Reactors resulted in the preparation of a monograph on experimental and numerical achievements in the field in the 21st century.

Two CRPs — on neutronics benchmark analysis of China Experimental Fast Reactor startup tests and on benchmark analysis of a test performed at the Fast Flux Test Facility in the United States of America — were completed, resulting in the validation of simulation tools and enhancement of models used for simulation of reactor neutronics, thermal hydraulics and coupled multiphysics.

### ***Nuclear fusion technology development for future energy production***

Participants in the Technical Meeting on Synergies Between Nuclear Fusion Technology Developments and Advanced Nuclear Fission Technologies discussed how the accumulated experience in developing, designing, constructing, operating and decommissioning nuclear power reactors and plants can help evolving fusion technology.



### **Non-electric applications of nuclear power**

The Agency initiated a new CRP on the Role of Nuclear Cogeneration within the Context of Sustainable Development, which will assess various nuclear cogeneration applications and will explore why and how countries could consider nuclear cogeneration in their portfolio of options to address climate challenges.

The Technical Meeting on Developing a Road Map for the Commercial Deployment of Nuclear Hydrogen Production explored ways to provide a useful management tool for evaluating, planning and strategizing the development of nuclear hydrogen projects.

The Technical Meeting on the Planning and Implementation of Nuclear Cogeneration Projects allowed Member States to exchange information on existing and planned nuclear cogeneration projects and to assess the latest developments in nuclear cogeneration worldwide.

At the eighth meeting of the Technical Working Group on Nuclear Desalination, members reviewed their national activities on nuclear desalination and integrated water management and provided recommendations to the Agency on plans for future activities in the area of nuclear desalination.

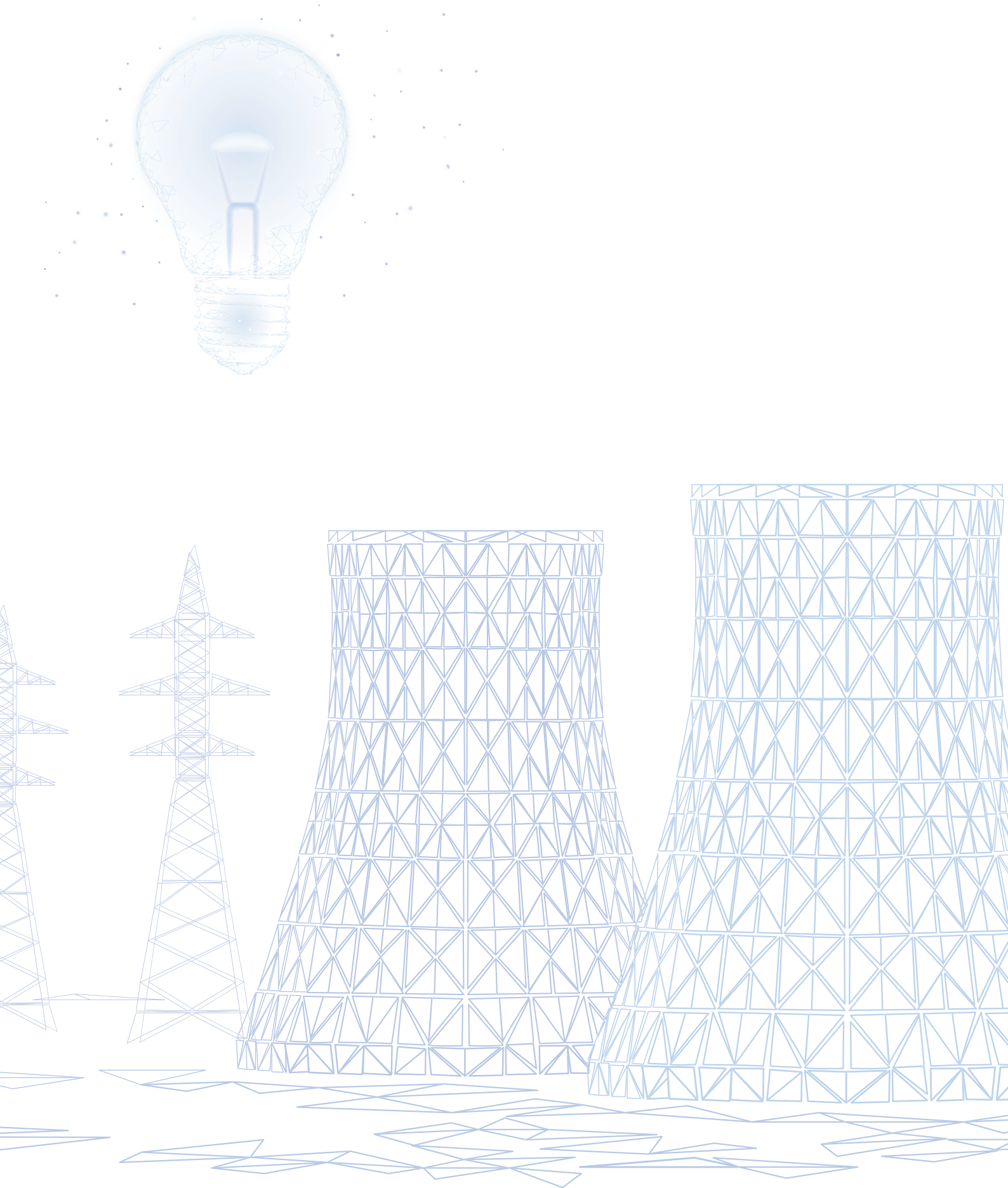
### **Enhancing Global Nuclear Energy Sustainability through Innovation**

At the 31st Meeting of the INPRO Steering Committee, Uzbekistan was welcomed as a new INPRO member, bringing the membership to 44. INPRO members discussed progress, the initiation of new INPRO collaborative projects, updates to the INPRO Strategic Plan for 2024–2029 and the development and launch of a new INPRO advisory service on strategic planning for the deployment of sustainable nuclear energy systems.

The publication *Case Study on Assessment of Radiological Environmental Impact from Normal Operation* (IAEA-TECDOC-1996) presents examples of different approaches for estimating environmental impact from normal operation of NPPs using case studies from several countries.

The first INPRO school at the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy, trained participants on the use of the INPRO methodology in assessing and analysing nuclear energy systems for sustainability.





## Agency Advances Support to African Newcomers with INIR Report for Uganda

Agency support to African Member States interested in introducing nuclear power advanced in 2022 as Uganda completed its first Integrated Nuclear Infrastructure Review (INIR).

In May, the Agency delivered the final report of its Phase 1 INIR mission to the Government of Uganda, a country of 43 million people that is looking to diversify an energy mix currently based primarily on hydropower as demand for electricity grows. “The INIR mission concluded that the Government of Uganda is committed to developing the required infrastructure for nuclear power in a coordinated approach with all concerned stakeholders”, said Aline des Cloizeaux, Director of the Agency’s Division of Nuclear Power, in the Ugandan capital Kampala, where she handed over the report to President Yoweri Kaguta Museveni.

“Uganda is developing nuclear power because hydropower alone will not be sufficient to meet national development targets”, said President Museveni, adding that, in addition to electricity generation, nuclear energy would be used for “medical and agricultural purposes”.

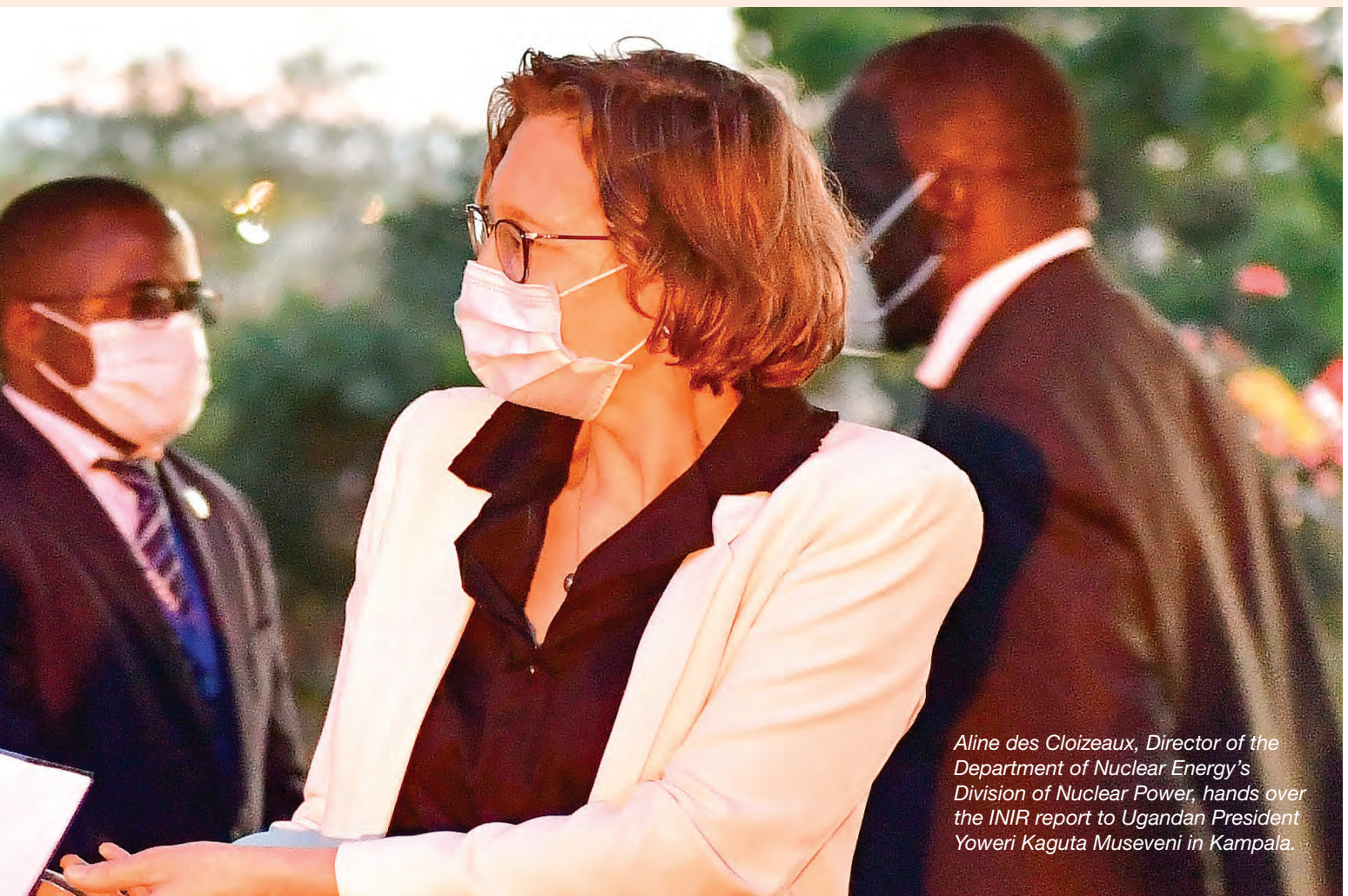
The INIR is a holistic peer review that supports Member States in assessing the status of national infrastructure for the introduction and development of a safe, secure and sustainable nuclear power programme. It is based on the IAEA’s Milestones Approach, a comprehensive methodology that systematically guides countries across three phases and 19 different nuclear infrastructure issues towards the introduction of nuclear power. Uganda is among several newcomers in Africa that have hosted INIR missions. Others include Egypt, which is building its first nuclear power plant, Ghana, Kenya, the Niger, Nigeria and the Sudan.



Following the INIR mission to Uganda in December 2021, the INIR team made recommendations and suggestions to assist the country in making further progress in its nuclear infrastructure development, in areas such as finalizing national policies to support its nuclear power programme, strengthening plans to develop a national legal framework and join international legal instruments, and completing various studies to better prepare for the next phase of programme implementation. The team also identified good practices in the areas of national position, stakeholder engagement and industrial involvement.

Uganda has conducted pre-feasibility studies and drafted a nuclear power road map that will guide the Government in making an informed decision on whether to proceed with the development of a nuclear power programme. It has also developed a national action plan to address the INIR report's recommendations and suggestions and, together with the Agency, will develop an Integrated Work Plan to identify Agency activities in support of efforts to develop the necessary nuclear power infrastructure.

This cooperation with Uganda took place as the Agency was showcasing other activities related to nuclear power in Africa, including in a dedicated chapter in the report *Climate Change and Nuclear Power 2022*, which was discussed at a side event on the energy transition at the 66th regular session of the General Conference. At COP27 in Egypt, the Agency held an event on nuclear energy in Africa, outlining perspectives and challenges in supporting the energy transition, as well as economic development and industrialization.



*Aline des Cloizeaux, Director of the Department of Nuclear Energy's Division of Nuclear Power, hands over the INIR report to Ugandan President Yoweri Kaguta Museveni in Kampala.*

# Nuclear Fuel Cycle and Waste Management

## **Objective**

*To support Member States in establishing effective, safe, secure and sustainable frameworks and solutions for the fuel cycle, radioactive waste management, decommissioning and life cycle management of related facilities, including research reactors, for nuclear programmes and nuclear applications. To support Member States in strengthening their capabilities and human resources in the domains of fuel cycle, radioactive waste management, decommissioning and environmental remediation, and research reactors. To be a platform to facilitate and strengthen international cooperation, coordination and information sharing among Member States.*

## **Uranium Resources and Processing**

Participants in the Technical Meeting to Collect and Document Innovations in the Uranium Production Cycle, held virtually, shared information and discussed technical innovations to make future low grade uranium deposits economically, technically and socially feasible.

## **Nuclear Power Reactor Fuel**

The publication *Fuel Failure in Normal Operation of Water Reactors: Experience, Causes and Mitigation* (IAEA-TECDOC-2004) provides an up-to-date review of data, experience and knowledge in the area of fuel failure during the operation of water cooled reactors.

Agency publications *Fuel Modelling in Accident Conditions (FUMAC)* (IAEA-TECDOC-1889) and *Analysis of Options and Experimental Examination of Fuels for Water Cooled Reactors with Increased Accident Tolerance (ACTOF)* (IAEA-TECDOC-1921) were translated into Arabic, Chinese and Russian.

The publication *Near Term and Promising Long Term Options for the Deployment of Thorium Based Nuclear Energy* (IAEA-TECDOC-2009) summarizes the results of a CRP on the topic. In particular, it presents the enhanced capabilities of thorium based fuels for high conversion ratio fuel cycles, improved inherent safety characteristics, and reduced minor actinide production.

Participants in the Technical Meeting on the Structural Behaviour of Fuel Assemblies in Water Cooled Reactors, held virtually, exchanged information on fuel design and operation, experimental data assessment, fluid–structure interactions, retrievability of used fuels, licensing aspects and regulatory acceptance.

## **Management of Spent Fuel from Nuclear Power Reactors**

Participants in the Technical Meeting to Identify Opportunities and Challenges in the Back End of the Fuel Cycle for Evolutionary Accident Tolerant Fuels, held virtually, developed a working definition

of such fuels and discussed the work under way to understand their impact on back end activities and to identify key questions and information needed.

Participants in the Technical Meeting on Back End of the Fuel Cycle Considerations for Small Modular Reactors identified the opportunities and challenges faced at all stages of the back end of the fuel cycle, the gaps in current infrastructure and the potential ways to move forward in addressing them in the near, medium and long term.

## Radioactive Waste Management

The publication *Experience in the Management of Radioactive Waste After Nuclear Accidents: A Basis for Preplanning* (IAEA Nuclear Energy Series No. NW-T-1.31) summarizes experiences and preparedness for managing waste in the event of a nuclear or radiological accident. The publication *Communication and Stakeholder Involvement in Radioactive Waste Disposal* (IAEA Nuclear Energy Series No. NW-T-1.16) provides practical guidance on the subject for countries embarking on, relaunching or revising a disposal programme.

Professional networks on predisposal and disposal were convened with a Technical Meeting organized for each network. The International Low Level Waste Disposal Network (DISPONET) meeting in Bulgaria focused on the closure of near surface disposal facilities, emphasizing the design and studies of the closure system at the beginning of the planning and construction phase.



Participants in the DISPONET meeting visited the national repository under construction at the Radiana site, Bulgaria.

### Management of disused sealed radioactive sources

The Agency published *Management of Disused Radioactive Lightning Conductors and Their Associated Radioactive Sources* (IAEA Nuclear Energy Series No. NW-T-1.15) highlighting aspects related to the recovery and dismantling of radioactive lightning conductors. The report *Management of Disused Sealed Radioactive Sources* (IAEA Nuclear Energy Series No. NW-T-1.3) was published and translated into Russian. In 2022, disused sealed radioactive source (DSRS) management support was rendered in Cambodia, Chile, the Congo, Greece, Jordan and Nepal.

Through the Technical Meeting on National and International Experiences in the Reuse and Recycling of Disused Sealed Radioactive Sources, practical strategies to deal with disused capsules were shared and contacts between potential DSRS donors and recipients were established.

## Decommissioning and Environmental Remediation

### Decommissioning

The Agency's Workshop on Characterization and Monitoring to Support the Management of Radioactively Contaminated Land enabled the sharing of good practices and experience related to characterization methodologies and technologies.

The publication *Decommissioning at a Multifacility Site: An Integrated Approach* (IAEA Nuclear Energy Series No. NW-T-2.13) provides practical guidance and examples of good practices in nuclear decommissioning. The Agency published *Training and Human Resource Considerations for Nuclear Facility Decommissioning* (IAEA Nuclear Energy Series No. NG-T-2.3 (Rev. 1)), which provides methodological guidance for, and specific examples of, good practices in training as an integral part of human resource management for staff performing decommissioning activities.

The Technical Meeting on Human Resource Development for Decommissioning enabled information to be shared and recent practices to be discussed, including issues of recruitment, motivation and retention. The Technical Meeting on the Use of E-Tools for Competence Building in Decommissioning and Environmental Remediation comprised detailed discussions and exchanges on current good practices and challenges in the use of digital technologies to promote competence development.

The International Workshop on Lessons Learned from the Implementation of Decommissioning Projects for Water Cooled, Water Moderated Power Reactors (WWERs), hosted by the Nuclear and Decommissioning Company (JAVYS) in Slovakia and supported by the European Commission and European Bank for Reconstruction and Development, allowed recent developments in WWER decommissioning projects in a preparatory phase and in progress to be shared and discussed.

The Technical Meeting on Preparation for Decommissioning for Research Reactors, the Technical Meeting on Ensuring Operator Preparedness for the Transition from Operation to Decommissioning and the International Workshop on Managing the Transition from Operation to Decommissioning, all held in Vienna, addressed all relevant aspects of preparation for decommissioning.

### Environmental remediation

The Agency organized the Biennial Forum of the Network on Environmental Management and Remediation, providing for the exchange of recent experiences and practices within remediation projects. The Workshop on Characterization and Monitoring to Support the Management of Radioactively Contaminated Land and a series of meetings on the management of naturally occurring radioactive material supported decision making and highlighted added value in transforming remediation liabilities into assets.

## Research Reactors

### Utilization and applications of research reactors

A new CRP on Development of Neutronic and Thermal-Hydraulic Coupled Computational Methodologies for Research Reactors Including Treatment of Uncertainties was launched to increase the knowledge and expertise of Member States in numerical analysis and to improve the design, operation, utilization and safety of research reactors.

The publication *Quality Assurance and Quality Control in Neutron Activation Analysis: A Guide to Practical Approaches* (Technical Reports Series No. 487) provides practical guidance on quality assurance and quality control in neutron activation analysis laboratories.

The consolidated results of a closed CRP were published as *Benchmarks of Fuel Burnup and Material Activation Computational Tools Against Experimental Data for Research Reactors* (IAEA-TECDOC-1992), which compiles the benchmark studies performed, for the benefit of operating organizations, researchers, regulatory bodies, reactor designers, technical support organizations and other parties interested in benchmarking the computer codes and models.

A new Neutron Applications Portal web platform was released with the main objective of serving as a unique source of information for research and applications using research reactors and accelerator-based neutron sources.

The Technical Meeting on Research Reactor Radioisotope Production, held in Vienna, discussed the demand and supply challenges of medical and industrial radioisotopes produced using research reactors, in preparation for a publication on the topic.

Participants in the tenth African Conference on Research Reactor Safety, Operation and Utilization, held in Cairo, discussed common issues, options and strategies and exchanged experience on good practices regarding safe management, effective operation and enhanced utilization of these facilities.

### ***New research reactor projects, infrastructure development and capacity building***

The Agency re-designated the Research Institute of Atomic Reactors in the Russian Federation as an International Centre based on Research Reactors, providing researchers from various countries the opportunity to use its unique experimental facilities.

A Training Workshop on the Preparation of a Feasibility Study for a New Research Reactor Project: Experiences and Challenges, and a Training Workshop on Technical Requirements in the Bidding Process for a New Research Reactor, provided participants with practical guidance on implementing important steps in developing new research reactor programmes following the Agency's Milestones approach.

Two Regional Research Reactor Schools conducted in Japan and the Russian Federation and the 17th Eastern European Research Reactor Initiative group fellowship held in Austria, the Czech Republic and Slovenia trained young professionals in a broad range of topics related to safe operation and effective utilization of research reactors.



*Participants in the Regional Research Reactor School attending practical training at the KUR research reactor, Kyoto University, Japan, October 2022.*



### Research reactor fuel cycle

The Agency published *Practices for Interim Storage of Research Reactor Spent Nuclear Fuel* (IAEA Nuclear Energy Series No. NF-T-3.10), which helps industry professionals at operating research reactors and storage facilities to identify the most suitable approach for interim storage of spent fuel.

A Technical Meeting on the Management of Irradiated Uranium Waste from Molybdenum-99 Production Using Low Enriched Uranium Targets provided a means for Member States to share experience of the disposition of waste products from their production of the world's most widely-used medical radioisotope. The Agency also cooperated in organizing and hosted the first Molybdenum-99 International Symposium.

A Technical Meeting on Lessons Learned from High Enriched Uranium Take-back Programmes kicked off the preparation of a publication that will assist in planning and executing shipments of spent research reactor fuel.

### Research reactor operation and maintenance

The Operation and Maintenance Assessment for Research Reactors (OMARR) missions in Chile and Poland helped these Member States to improve the availability and reliability of their research reactors.

Technical Meetings on Utilization Related Design Features of Research Reactors, on Operation, Maintenance and Ageing Management for Research Reactors, and on Preparation for Decommissioning for Research Reactors allowed participants to share their experiences of managing different stages of the research reactor life cycle.

Participants in a Training Workshop on Non-Destructive Examination, In-Service Inspection and Online Monitoring Techniques of Research Reactors acquired information on the topic and practical training at an operational research reactor.



*Hands-on training on in-service inspection at the TRIGA II research reactor of the Vienna University of Technology, April 2022.*

# Capacity Building and Nuclear Knowledge for Sustainable Energy Development

## Objective

*To support Member States in strengthening their capacities for formulating robust energy strategies, plans and programmes, and to improve their understanding of nuclear energy's contribution to facilitating the clean energy transition, combating climate change and achieving the SDGs. To support Member States in strengthening their capacities for establishing, managing and using their nuclear knowledge base and to foster international networking. To acquire, preserve and provide Member States with access to information in the area of nuclear science and technology and to facilitate sustainable information sharing among Member States.*

## Energy Modelling, Data and Capacity Building

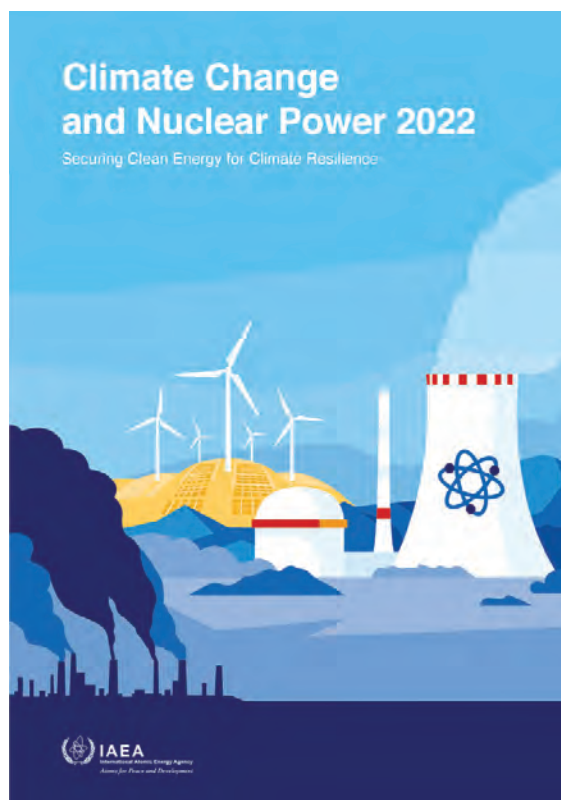
Planning for tomorrow's energy systems, whether at the national or at the regional scale, requires addressing multiple challenges, such as meeting energy demand as well as climate and sustainable development objectives, while considering the interlinkages between climate, land use, energy and water. The modelling support provided by the Agency to African Member States involved in the development of the Continental Power Systems Master Plan, Africa's future integrated electricity system, helped them in developing national energy strategies. Moreover, the Agency, the Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology for Asia and the Pacific, and the Asian Development Bank made concerted efforts to showcase the Agency's energy planning support activities, resulting in renewed support being provided to Member States in the Asia-Pacific region.

An increasing number of Member States pledged to decarbonize fully by the middle of the century or thereafter. The Agency started to develop a dedicated analysis of the contribution of nuclear power technologies, including small modular reactors, to providing low carbon energy in energy supply scenarios.

## Energy Economy Environment (3E) Analysis

Ahead of COP27, the Agency published the 2022 edition of *Climate Change and Nuclear Power*, which examines, among other things, prospects for nuclear power deployment in Africa to address climate and economic development objectives; provides detailed analysis of the impact of climate change on nuclear power generation; and discusses nuclear power's contribution to the resilience of energy systems. Several of these topics were also discussed at the events held at the Agency's #Atoms4Climate pavilion at COP27.

A Workshop on the Economics of the Current Generation of Nuclear Power Plants, held virtually, and a Technical Meeting on Costing Approaches for Nuclear Infrastructure Development, hosted by the Czech Republic, promoted the understanding and development of cost analysis for nuclear projects. A Technical Meeting to Review and Finalize the IAEA Publication on Financing Nuclear Power Plants in Evolving Markets increased awareness of the available mechanisms and enabled the sharing of national experience.



*The Climate Change and Nuclear Power report has been published by the Agency since 2000. Building on energy statistics and climate change scenarios, the report outlines the potential contribution of nuclear power to a decarbonized, secure global energy system.*

Better understanding of the role of nuclear hydrogen in the clean energy transition was achieved through an International Workshop on the Role of Low Carbon Hydrogen for a Net Zero Energy System, organized with the International Energy Agency's Hydrogen Technology Collaboration Programme.

The Agency published *Alternative Commercialization Pathways for Fusion Energy Systems* (IAEA-TECDOC-1997), bringing together expert opinions from the diverse range of disciplines that are essential to fusion's commercial success. It highlights several critical aspects to consider for new pathways and sketches an outline of a road map for their development.

The Second IAEA Workshop on Fusion Enterprises, hosted virtually by the United Kingdom Atomic Energy Authority, discussed the market demands and commercialization opportunities for future fusion energy.

## Nuclear Knowledge Management

Three Technical Meetings on nuclear knowledge management supported professionals worldwide in maintaining and preserving the technical expertise and skills required for nuclear power programmes and other nuclear technologies.

The publication *Guide to Knowledge Management Strategies and Approaches in Nuclear Energy Organizations and Facilities* (IAEA Nuclear Energy Series No. NG-G-6.1) gives guidance on developing and implementing a strategic knowledge management programme as a proactive measure, to reduce the risk of knowledge loss and to provide safety and financial benefits.

The Agency also published *Mentoring and Coaching for Knowledge Management in Nuclear Organizations* (IAEA-TECDOC-1999), which highlights the importance of mentoring and coaching for knowledge transfer across the generations within the workforce.

The publication *Nuclear Educational Networks: Experience Gained and Lessons Learned* (IAEA-TECDOC-2007) provides the background, context and drivers for developing and promoting collaboration in nuclear educational networks, capturing best practices and mechanisms that can aid the establishment and operation of such networks.

International Nuclear Management Academy (INMA) review missions took place to review progress in developing the INMA programmes in the Czech Republic, the Republic of Korea, and the United States of America. The missions were conducted to evaluate the feasibility of implementing a nuclear technology management master's programme at selected universities.

The Agency re-designated the National Atomic Energy Commission of Argentina as a Collaborating Centre for human resources development in the area of nuclear science and nuclear technology and their applications.

The new digital Nuclear Knowledge Management Hub on the IAEA CONNECT platform continued to expand and showcase a wide range of online processes, methodologies and guidance for Member States across a broad spectrum of knowledge management and nuclear educational services.



## Nuclear Desalination Workshop Supports Water-scarce Jordan

Facing extreme water scarcity, Jordan turned to the Agency to learn more about seawater desalination using small modular reactors. The country, which is considering the introduction of nuclear power, requested support through the IAEA Platform on Small Modular Reactors and their Applications, which facilitates Member States' access to Agency support on all aspects of the development, deployment and oversight of such reactors.

The Agency organized a four-day workshop in November 2022 in the capital, Amman, where 18 participants from various Government ministries and the Jordan Atomic Energy Commission (JAEC) were given an overview of the technical and economic aspects of nuclear desalination technologies and systems, their coupling with small modular reactors, siting requirements, and the experience of Agency Member States with nuclear desalination. The workshop introduced the Agency's software tools for evaluating the performance and costs of desalination systems, using both membranes and distillation-based methods, coupled to nuclear reactors and to other energy sources. Participants also developed their own basic methodology for calculating the performance of NPPs coupled to a multi-effect distillation system.

As the second-most water-scarce country in the world, Jordan must develop desalination capabilities, Khaled Touqan, Chairman of the JAEC, remarked at the workshop. "The JAEC is now considering the deployment of SMR technology due to its load following power generation and cogeneration capabilities for a wider range of users and applications, enhanced safety features, and better economic affordability," he said, adding that "the unique features of SMRs are expected to affect siting considerations and environmental impact assessment."



Desalination plants require heat for distillation, or electrical/mechanical energy to power pumps that drive seawater through membranes. Currently, most of this energy is derived from fossil fuels, but nuclear desalination is a low carbon alternative that utilizes the electricity, and possibly also the heat, from nuclear plants.

“An increasing number of Agency Member States are expressing interest in using nuclear energy to address their water scarcity challenges,” said Francesco Ganda, who led the workshop and is Technical Lead for Non-Electric Applications in the Agency’s Department of Nuclear Energy. “The emergence of SMRs is offering more options to countries to use nuclear energy not only for power generation but also non-electric applications such as seawater desalination and for producing hydrogen, process heat for industry and heat for buildings.”

The feasibility of integrated nuclear desalination plants has been proven with over 150 reactor-years of experience, mainly in India, Japan and Kazakhstan. Aktau NPP in Kazakhstan, on the Caspian Sea, produced up to 135 MW(e) of electricity and 80 000 m<sup>3</sup> per day of potable water for 27 years until it was shut down in 1999. In Japan, several desalination facilities linked to nuclear reactors produce about 14 000 m<sup>3</sup> per day of potable water.

In southeast India, a demonstration plant producing a total of 6300 m<sup>3</sup> per day is coupled to the pressurized heavy water reactors at the Madras Atomic Power Station. This is the largest seawater desalination plant based on hybrid thermal and osmotic technology that uses low pressure steam from an NPP.

Jordan has worked closely with the Agency for more than a decade in developing the infrastructure for introducing nuclear power, including hosting INIR missions, most recently in 2014. The country has identified three possible sites for a future NPP, conducted feasibility studies for deploying some SMR designs, and prepared specifications for a bid invitation with support from Agency experts.



*Participants from Jordanian Government ministries and the JAEC performing a numerical exercise during the workshop, held in Jordan, which guided them to develop a simple computational model to evaluate the performance of desalination systems coupled to nuclear plants.*

# Nuclear Science

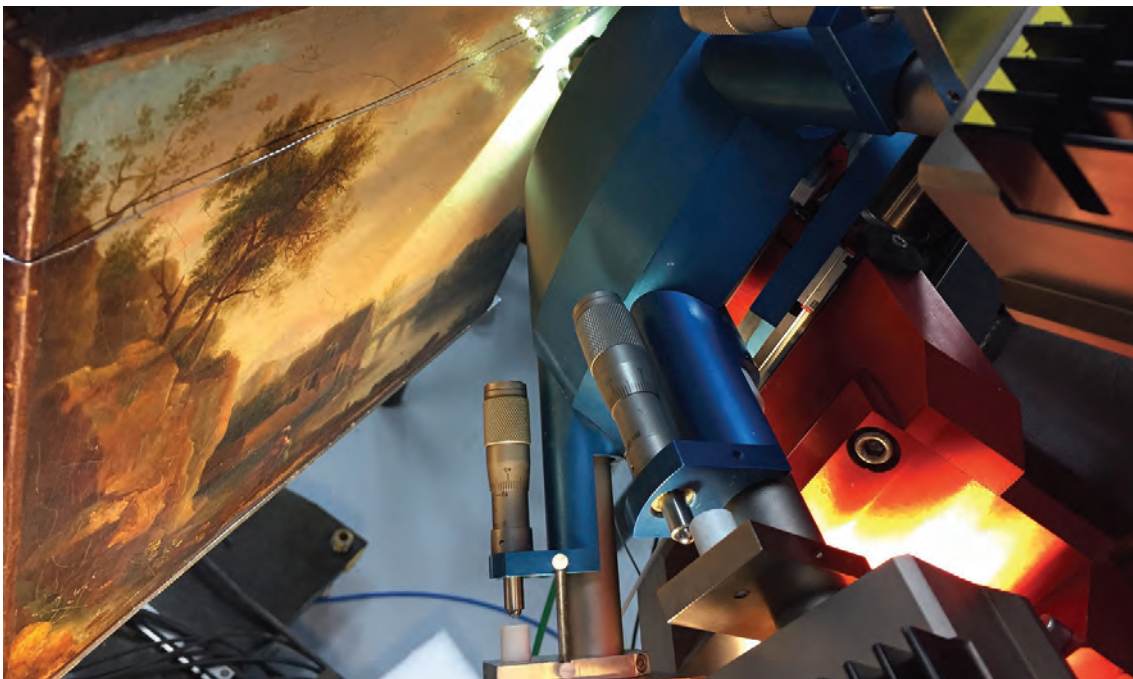
## Objective

*To support Member States in strengthening their capabilities in the development and application of nuclear science as a tool for their technological and socio-economic development. To support Member States in enhancing sustainable operation and effective utilization of particle accelerators and neutron sources, as well as effective utilization of research reactors, increasing opportunities for access to these facilities and their diverse applications, and in developing relevant qualified professionals.*

## Atomic and Nuclear Data

Technical Meetings on atomic data for fusion plasma and wall materials resulted in three updated databases for atomic interactions and radiation damage — ALADDIN, CascadesDB and DeFecTdb. The databases were reformatted to make them ready for use in machine learning applications for nuclear fusion.

The Agency collaborated on the International Conference on Nuclear Data for Science and Technology, held virtually, where the accomplishments of Agency projects on nuclear reaction and nuclear structure physics were presented.



*Ion beam analysis at the AGLAÉ facility in the Louvre Museum of an untitled and anonymous painting on canvas likely from the French school, dating from the 17th–18th century.*

## Research and Applications with Accelerators and Neutron Sources

Together with partner organizations, 24 experiments at Elettra Synchrotron Trieste, Italy, and 14 at the Ruđer Bošković Institute, Croatia, were carried out by groups from about 20 Member States.

Expert missions to ion beam accelerators in Ghana and Lebanon diagnosed problems and advised on improved utilization.

The May 2022 edition of the IAEA Bulletin, on Applications of Accelerators and Other Sources of Ionizing Radiation, examines Agency support for accelerator applications in health, agriculture, research, the environment and industry.

Ten scientific papers from the CRP on Enhancing Nuclear Analytical Techniques to Meet the Needs of Forensic Science appeared in a special issue of the *Forensic Science International* journal, and a Training Workshop on the Applications of Accelerator-Based and Complementary Techniques for Forensic Science, held in Lecce, Italy, covered nuclear analytical techniques for forensic applications.

A new e-learning course on Specific Considerations and Guidance for the Establishment of Ionizing Radiation Facilities offers guidance through the phases of planning and establishing facilities.

Training courses and workshops provided hands-on training on analytical techniques and operations and maintenance at ion beam and synchrotron facilities.

The Technical Meeting on Best Practices in Boron Neutron Capture Therapy discussed improved cancer treatment using accelerator-based boron neutron capture therapy facilities.

The Joint IAEA–ANL Training Course on Strategic Planning and Management for Young Leaders and an online course on Strategic Planning and Integrated Management Systems for Ionizing Radiation Facilities and Associated Infrastructure introduced tools and methodologies for the effective management and operation of research facilities and activities.



*The trainees working in the Agency's Nuclear Science and Instrumentation Laboratory in Seibersdorf.*



## Nuclear Instrumentation

The publication *Muon Imaging: Present Status and Emerging Applications* (IAEA-TECDOC-2012) describes some of the main muon imaging techniques, the detector types involved, and a wide variety of practical applications.

More than 200 person-weeks of hands-on training took place at the Nuclear Science and Instrumentation Laboratory in Seibersdorf, Austria, covering gamma spectroscopy, X-ray fluorescence (XRF), radiological mapping, radiotracer applications and neutron science.

The analytical capabilities of 80 laboratories in 52 Member States were improved via proficiency tests.

Group fellowships at the Seibersdorf laboratories provided hands-on exercises on radiation detection and applications using scintillation, gamma spectroscopy, portable detectors, and XRF- and neutron-based techniques.

The Technical Meeting on the Use of Uncrewed Aerial Systems for Radiation Detection and Surveillance held in Brno, Czech Republic, demonstrated the use, capabilities and specifications of such systems for radiation detection and surveillance.

The Joint ICTP–IAEA Workshop on Advanced Solutions for Field Measurements held in Trieste discussed georeferenced measurements in stationary, walking and drone-based surveys.

## Nuclear Fusion Research

At the 11th ITER International School, organized in cooperation with the Agency, students were acquainted with advances in fusion research and technology.

The Agency launched a new CRP on Artificial Intelligence for Accelerating Fusion Research and Development with the overall objective of accelerating fusion R&D with AI through the creation of a platform and cross-community network for innovation and partnership.

A five-year CRP involving 13 institutes, working on various practical applications of compact fusion neutron sources, was completed and the results published in *Development of Steady State Compact Fusion Neutron Sources* (IAEA-TECDOC-1998).

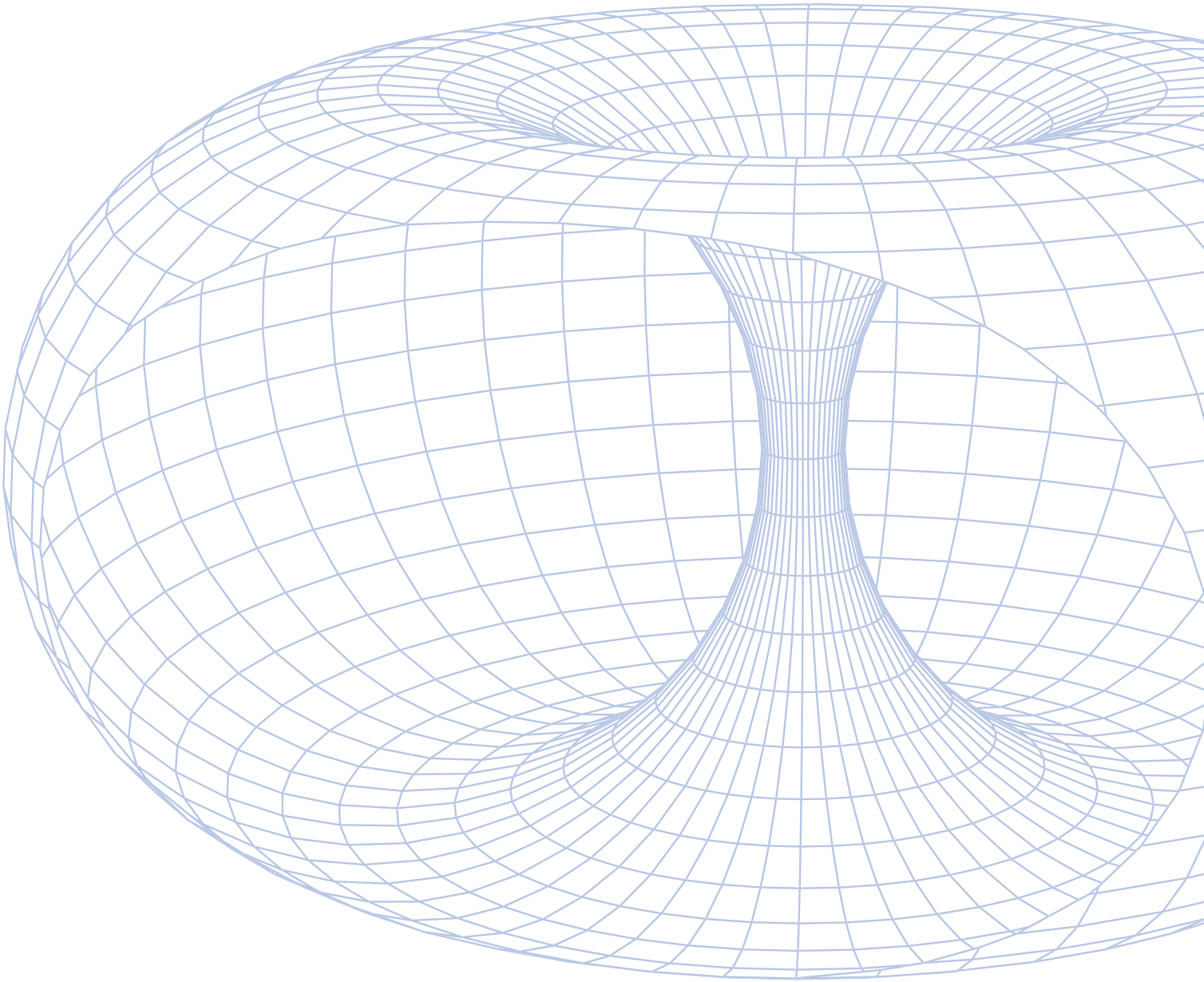
During the Eighth IAEA DEMO Programme Workshop, held in Vienna, experts discussed operational transients, coolant technologies, the tritium fuel cycle and required materials research for future DEMO fusion plants.

Technical Meetings on fusion research and technology enabled information to be exchanged on plasma disruptions and their mitigations, plasma–wall interactions, divertor concepts, long-pulse operations and joint experiments.

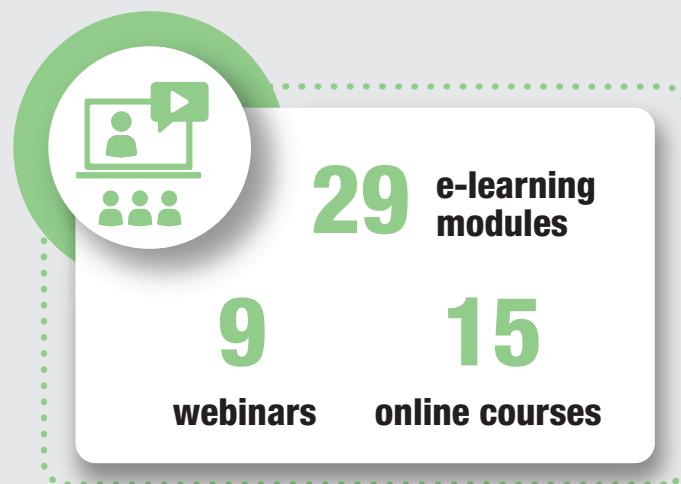
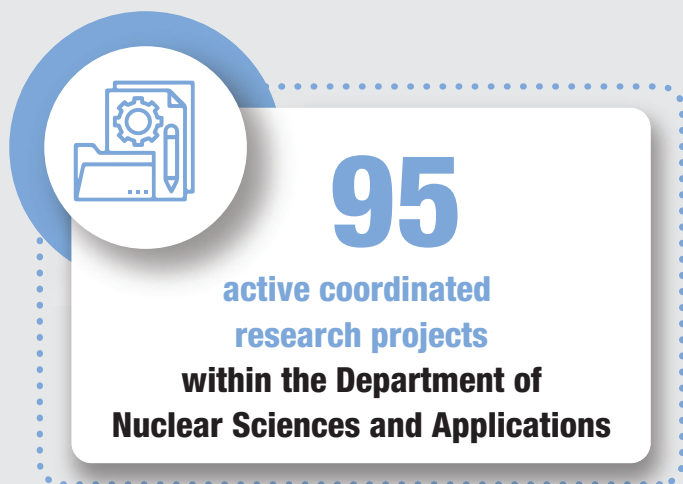
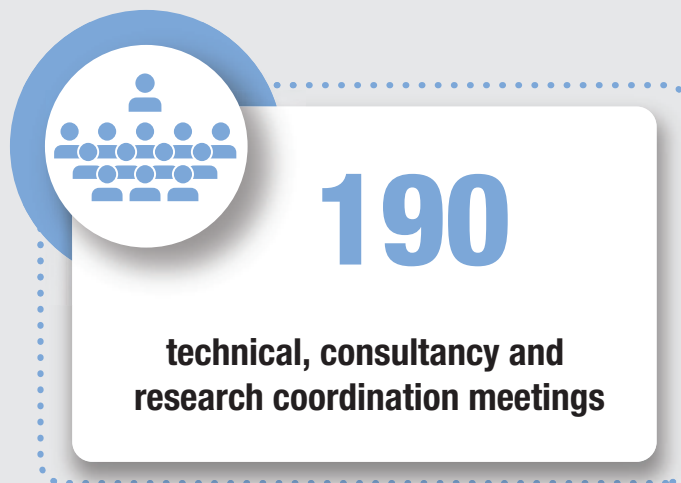
A Joint ICTP–IAEA College on Plasma Physics for Fusion Applications held in Trieste covered the latest developments and emerging applications, including nuclear energy, on the basis of which an e-learning course was developed.

Another e-learning course on Nuclear Fusion and ITER Science and Technology was released, covering the science and technology of ITER and associated research.

The Agency organized the first three webinars in the ‘Building Stars – Breakthroughs in Fusion R&D’ series, focusing on the latest landmark achievements announced in fusion worldwide. The series gives an overview of recent groundbreaking results and puts them in perspective, explaining how such progress brings fusion energy closer to realization.



# Nuclear Techniques for Development and Environmental Protection



# 2022



## Human Health Campus

**108 445**  
users

**336 789**  
page views

**84%**  
new users



**1082**  
active  
research contracts



**165**  
training courses  
and workshops



**69**  
publications

**48**  
guidelines  
**250**  
external  
publications



**44**  
active Collaborating Centres  
within the Department of  
Nuclear Sciences and Applications



**13**  
collaboration networks

# Food and Agriculture

## Objective

*To increase the sustainability and resilience of food and agriculture production and related livelihoods in Member States through climate-smart agriculture approaches, including meeting challenges from animal and zoonotic diseases, plant pests, food safety risks, climate change, biothreats, and nuclear or radiological emergencies.*

## ZODIAC

The Agency's Zoonotic Disease Integrated Action (ZODIAC) initiative supports primarily the early detection, analysis and characterization of pathogens, thus providing scientific evidence to veterinary and public health authorities to aid dynamic decision making and the control of outbreaks of emerging and re-emerging zoonotic diseases.

By the end of 2022, 126 ZODIAC national laboratories (ZNLs) in Africa (43), Asia and the Pacific (25) Europe (37) and the Americas (21), and 150 national coordinators (ZNCs) from Africa (44), Asia and the Pacific (34), Europe (42) and the Americas (30) had been designated by their respective authorities to coordinate activities and become part of the ZODIAC laboratory network, which in turn is part of the Veterinary Diagnostic Laboratory (VETLAB) Network.

In 2022, numerous ZODIAC activities were implemented as part of capacity building and technology transfer. The Agency supported the procurement of equipment and consumables for serological and molecular detection of zoonotic pathogens; packages for advanced characterization of zoonotic pathogens (Sanger and whole-genome sequencing); biorisk (biosafety and biosecurity) management packages; and complementary packages to integrate these techniques according to ISO/IEC 17025 standards.

Several virtual interregional courses were conducted on generic verification of standard operating procedures for serology and molecular diagnostics and on the use of the Agency's genetic sequencing services. In total, around 700 participants attended the courses and 20 new registrations were obtained for the Agency's sequencing services. In addition, ad hoc individual training courses were provided for three scientists from Indonesia, Senegal and Tunisia on whole-genome sequencing at the Agency's Seibersdorf laboratories to enhance the capacity of ZNLs in the early and rapid detection and characterization of re-emerging zoonotic pathogens. In the ZODIAC Portal, additional training material was made available on genetic sequencing services, standard operating procedures for serological and molecular techniques, and how to use the iVETNet platform.

The first expert meeting on biorisk management system implementation in ZNLs convened 20 experts from the Food and Agriculture Organization of the United Nations (FAO), the World Organisation for Animal Health, US Centers for Disease Control and Prevention, Philipps-Universität Marburg, South Africa's National Institute for Communicable Diseases and the Africa Centres for Disease Control and Prevention, and established an initial list of procedures for biorisk management to be developed as standard operating procedures.



*Molecular training course to build capacities in Member States. (Photograph courtesy of Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture)*

Four coordinated research projects (CRPs) were designed with the support of international senior experts to develop and validate pathogen detection technologies, in order to improve laboratory preparedness and capacity for the surveillance, early detection, control and prevention of major emerging zoonotic diseases in each region. Under the CRP for Asia and the Pacific, three technical contracts were awarded to develop environmental sampling methods (e.g. 'sniffer' technologies).

The FAO/IAEA Agriculture and Biotechnology Laboratories in Seibersdorf worked on the development, testing and/or validation of commercial kits related to the detection of the COVID-19 virus. Eight commercial quantitative PCR-based detection kits were tested and considered suitable and the findings were published in a peer-reviewed journal paper. In addition, two luciferase immunoprecipitation systems (LIPS-N, LIPS-S) were compared with two commercial N-based enzyme-linked immunosorbent assays (ELISAs) for the detection of antibodies against the COVID-19 virus in mink. Results showed that the LIPS-S assay was more accurate than ELISAs for serological surveillance within a naturally exposed mink population, as it provided a lower number of false negative results. Finally, a SARS-Cov-2 assay for antibody detection in different animal species was developed using LIPS. Results indicated the suitability of the assay for the sero-surveillance of COVID-19 virus infection in a range of animal species.

## Seeds in Space

Evolution in organisms is driven by mutations arising from exposure to various environmental stimuli. Member States have used radiation-induced mutagenesis and plant breeding to develop improved plant varieties with specific characteristics, including increased yield, enhanced quality, resistance to pests and diseases and suitability for harsh climates. Historically, gamma rays and X-rays have been the predominant agents used to induce genetic variation for plant mutation breeding. However, the unique conditions of microgravity and radiation in space have motivated

a series of biological experiments at the International Space Station (ISS) and in simulated space environments at facilities such as the NASA Space Life Sciences Laboratory. In 2022, the Agency and FAO, through the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture, ventured for the first time into astrobiology and space breeding with a feasibility study on seed irradiation in space for induced genetic diversity and plant mutation breeding. As part of the study, seeds of the plant species *Arabidopsis thaliana* and *Sorghum bicolor* were sent to space in the cargo of the CRS2 NG-18 mission that launched from NASA's Wallops Flight Facility. These seeds are currently being hosted both within and outside the ISS to increase available knowledge on the effect of cosmic radiation and microgravity on induced genetic variation, and on the use of these phenomena to develop crops that can withstand harsh growing conditions on Earth. The seeds will return from the ISS in early 2023, to be systematically evaluated at the Agency's Laboratories at Seibersdorf to determine the effects of the space environment on genetics and biology.

## Antimicrobial Resistance

Agricultural systems are increasingly polluted by antimicrobial substances, including antibiotics used to prevent and treat infections in humans and animals. While these substances save lives, their misuse and overuse are the main drivers for the development of drug-resistant pathogens. The World Health Organization (WHO) has declared antimicrobial resistance one of the top ten global public health threats, causing 700 000 deaths each year and projected to cause 10 million deaths by 2050. To date, the issue has been approached mainly from the human and animal health angles; however, little is known about the impacts of antimicrobial resistance in the environment. It is unknown to what extent antibiotics and resistant bacteria spread through soil and water run-off and via the deep percolation of human and animal waste in agricultural systems. Therefore, it is crucial to gain a better understanding of how antimicrobial resistance moves through soil and water in agricultural systems.

In 2022, through a CRP entitled 'Isotopic Techniques to Assess the Fate of Antimicrobials and Implications for Antimicrobial Resistance in Agricultural Systems', the Agency developed techniques to monitor the pathway of the synthesized antibiotic sulfamethoxazole (SMX) in soil carbon turnover processes based on the application of <sup>13</sup>C-labelled glucose and SMX. Compound-specific stable isotopes of carbon and nitrogen as well as stable isotope probing techniques were used to trace the dynamics of SMX in soil, plants and the environment. While these studies effectively showed



Spreading manure to increase soil fertility releases both antimicrobials and their metabolites (antimicrobial genes) into the field. (Photograph courtesy of the Chesapeake Bay Program)



*Iranian scientists vaccinate a chicken against avian influenza using an experimental irradiated-inactivated vaccine. (Photograph courtesy of Prof. Farahnaz Motamedi-Sedeh)*

that the degradation of SMX led to a loss of soil carbon, additional studies are required to better understand the pathway and dynamics of applied antibiotics and implications for antimicrobial resistance in agricultural systems.

## **Irradiated Vaccines**

There is a great need to accelerate the design and development of new vaccines to protect against emerging and re-emerging pathogens that are difficult to control and can cause devastating epidemics. Within the framework of the VETLAB Network, initial irradiated vaccine projects established the basic parameters required to carry out preliminary experiments in Member States.

To support participating laboratories further, VETLAB laboratories have developed tools that can be used to evaluate vaccine efficacy. For instance, quantitative PCR panels, which measure innate and adaptive immunity, have been developed for ruminants, swine and poultry. These PCR panels are easy to adopt, which is especially important for collaborating partners that have limited resources to carry out other assays. In addition, a more complex assay that measures vaccine immunogenicity *in vitro* using bovine monocyte-derived dendritic cells was developed for use as a filter for antigens before proceeding to animal experiments.

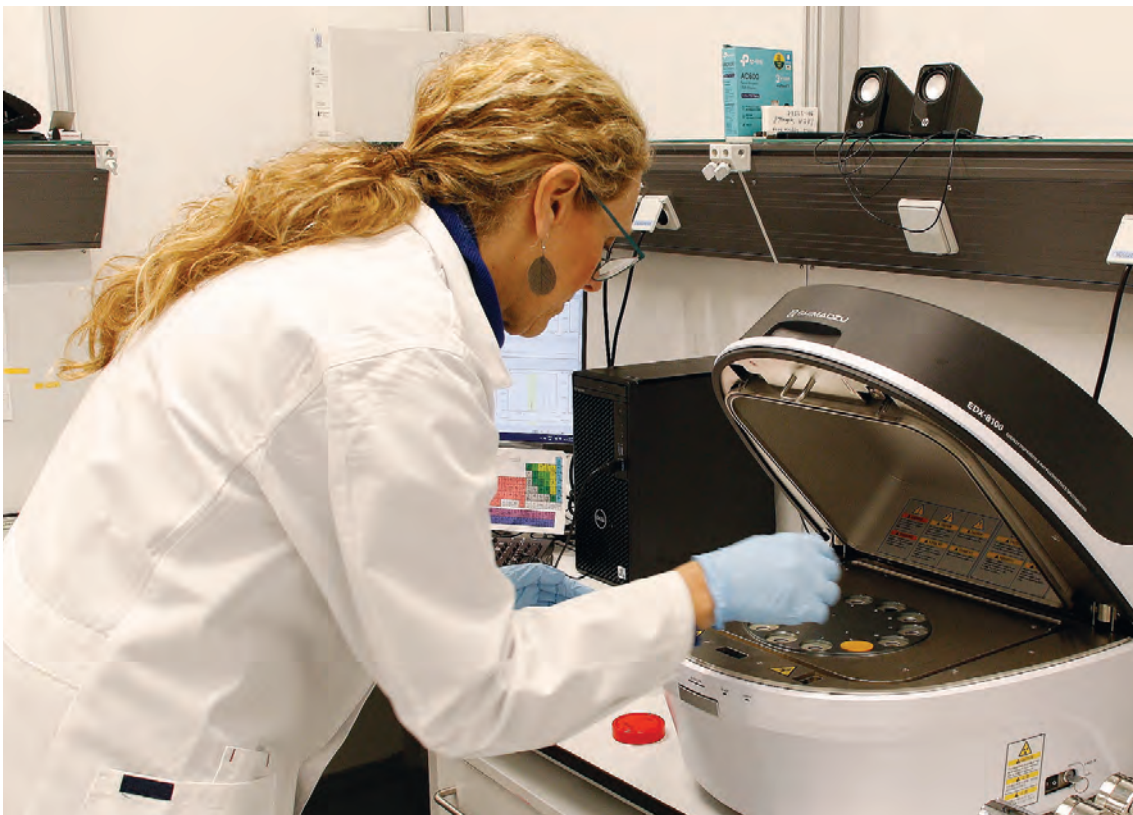
Through the Joint FAO/IAEA Centre, the Agency launched a Frontiers research topic on irradiation technologies for vaccine development. There are already 15 articles published under the research topic, including an article on the development of vaccines to protect against influenza, a priority disease according to the One Health approach. Through the research topic it was found that irradiated sterilizing doses maintained structural integrity and vaccine efficacy in all preparations, regardless of the irradiation temperature, and that irradiated vaccine formulations based on inactivated influenza virus demonstrated potential for better performance than conventional vaccines, in terms of both reducing shedding and preventing infection.



## Food Safety and Authenticity

Member States face many challenges in ensuring a sustainable, safe and nutritious food supply. Recent events such as the COVID-19 pandemic have highlighted several vulnerabilities in food control systems, including inadequate capability to deal with sudden events that impair operations and to detect and rapidly respond to the emergence of new food-borne diseases and hazards. As such, there is a need for rapid testing methods to improve food safety and quality surveillance. In this regard, nuclear and complementary screening methods can be applied at different points along the food supply chain to aid decision making and ensure that contamination events can be promptly investigated. These methods not only reduce reliance on costly laboratory testing but can also be performed by relatively unskilled personnel.

In 2022, under a project to enhance Member State capacity to rapidly respond to food safety incidents and emergencies, the Agency developed rapid screening methods and laboratory-based methodologies, such as stable isotope ratio and other mass spectrometric measurements, for several techniques including energy dispersive X-ray fluorescence spectrometry, ion mobility spectrometry, surface-enhanced Raman spectroscopy and Fourier transform near-infrared spectroscopy. These methods and laboratory-based methodologies were used to detect toxic Sudan dyes added to spices, palm oil and other commodities with a view to enhancing their perceived quality and value; to verify the geographical origin of commodities such as Thai Hom Mali rice and honey; and to detect residues of agrochemicals such as neonicotinoid pesticides, which are implicated in the decline of pollinating bee populations, in foods. In 2022, more than 240 scientists from 43 Member States were trained by the Agency in these techniques.



*Development of a method to test spices for safety and quality using energy dispersive X-ray fluorescence spectrometry at the Joint FAO/IAEA Centre laboratories in Seibersdorf.*

## Nuclear Technique Successfully Eradicates Dangerous Pest Infestation in Mexico

In 2021, Mexico faced a major threat to its agricultural produce when an outbreak of Mediterranean fruit fly, or medfly, was detected in the country's southwestern state of Colima, near the border with Guatemala. One of the most destructive insect pests affecting fruits and vegetables, the medfly posed a considerable threat to farmers' livelihoods and the country's economy. Just one year later in 2022, the Mexican authorities reported that the outbreak had been successfully overcome with the help of the sterile insect technique (SIT) — a nuclear technique applied under the guidance of the Agency in partnership with the Food and Agriculture Organization of the United Nations (FAO).

The medfly is considered a major agricultural pest because it feeds on a wide range of crops and is difficult to control. After the insect lays its eggs inside a fruit, the larvae feed on the fruit's flesh, rendering it inedible and unsellable. The Colima outbreak posed a serious threat to Mexico's production of oranges, figs, mangoes and papayas, among other agricultural products.

Various methods can be applied to control medfly infestations, some of which are costly and could have negative impacts on crops and the environment. In contrast, the SIT is one of the most efficient and environmentally friendly control methods. Serving as a form of birth control for pests, it involves the mass rearing and sterilization of male insects using low doses of ionizing radiation. When those insects are subsequently released into nature, they mate with wild females but produce no offspring. As a result, the insect population gradually shrinks and is eventually eradicated. This is the second time the SIT has helped eliminate the medfly threat in Mexico — in 1982, national experts used the nuclear technique to effectively wipe out the pest.

*The Mediterranean fruit fly can infest hundreds of varieties of fruits and vegetables.*



As pests can cross borders easily, it is important to be able to respond quickly to new outbreaks when they occur. Following the 2021 outbreak, Mexico opened a new facility specially designed with Agency assistance to produce sterile insects. The second largest facility of its kind in the world, it is capable of rearing one billion sterile flies per week. The goal is to consolidate the current containment barrier at Mexico's border with Guatemala and gradually eliminate the medfly from an area stretching from Guatemala all the way to Panama.

"In the past, the Mediterranean fruit fly has been a big threat to the horticultural industry in Mexico and we have developed large scale programmes to defeat and contain its spread along our southern border", said Maritza Juarez Durán, Director of the National Fruit Fly Programme (PNMF) at Mexico's National Service for Food Health, Safety and Quality (SENASICA). "The detection of this pest in Colima in April last year, 1300 km from the closest wild populations located in the state of Chiapas, at the border area between Mexico and Guatemala, was alarming and we value the IAEA's and FAO's support in helping us bring it under control."

After receiving an emergency request from Mexico, the Agency and FAO responded immediately, organizing on-site visits by individual experts who reviewed the emergency response deployed by the Mexican plant protection organization and provided recommendations for adjusting the eradication strategy. In addition, a technical advisory panel led by Agency staff reviewed the implementation of the eradication actions and provided advice on the post-eradication phase and on regaining 'fruit fly free' status. Specific materials and equipment were also supplied to support the eradication activities.

Mexico is the world's seventh largest exporter of agricultural products and the use of the SIT helps keep these products free from invasive pests, ensuring food security in the region. The Agency continues to assist and work with Mexico through national and regional technical cooperation projects, and through the PNMF, an Agency Collaborating Centre.



# Human Health

## Objective

*To support Member States in enhancing their capability to address needs relating to nutrition and the prevention, diagnosis and treatment of health problems through the development and application of nuclear and related techniques within a quality assurance framework.*

## Rays of Hope

The Agency's Rays of Hope initiative aims to increase access to quality radiation medicine for cancer in countries with little to no access or inequitable access by fully integrating the support delivered to Member States.

In 2022, the Agency provided technical support to identify a first wave of priority Member States and their current needs and gaps in radiation medicine. Benin, Chad, the Democratic Republic of the Congo, Kenya, Malawi, the Niger and Senegal were selected and tailored plans were developed to support their respective needs. Each plan covers education and training needs for all relevant disciplines and equipment. As part of Rays of Hope, regional anchor centres will be identified to work as regional leaders, contributing to best practices in radiation medicine while enhancing professional development. In 2022, the Agency streamlined the application process and defined specific requirements for anchor centres, which have been made available to Member States through a dedicated section on the Agency's webpage and an information brochure. Letters of interest were received from over ten countries and are at different stages of the evaluation process.

Under Rays of Hope, the Agency and 11 professional societies signed Practical Arrangements to work together to improve access to radiotherapy services and reduce global inequities in cancer treatment. The Practical Arrangements cover various regions and focus on radiation oncology, medical physics and diagnostic imaging. With the signing of these Practical Arrangements, the Agency aims to enhance support to anchor centres by strengthening their educational and training programmes and bringing innovation and research to an advanced level.



*The Director General opening the Rays of Hope Donor Roundtable, 13 June 2022.*

## ZODIAC

Pillar 4 of the ZODIAC initiative focuses on the implementation of cloud-based solutions to enhance data processing, data analysis and collaboration for improved detection and characterization of zoonotic pathogens through the creation of a Respiratory Disease Phenotype Observatory. By 2026, the ZODIAC Respiratory Disease Phenotype Observatory will be collecting a continuous stream of imaging data and associated clinical data from patients around the world with respiratory diseases.

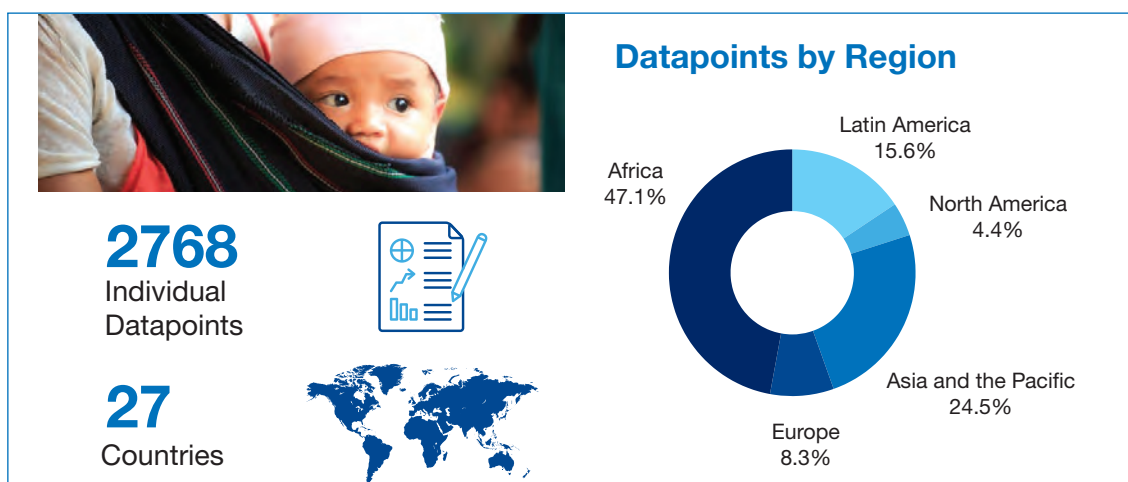
To make the Observatory a reality, in March 2022, the Agency held a an in-person stakeholders meeting with Agency experts and representatives from Amazon Web Services, the University of Vienna, the Fraunhofer Institute for Digital Medicine, Radboud University and Contextflow to define the technical aspects of the cloud-based solution that will host and manage the dataset of this repository.

The revision of the proposals for the coordinated research project (CRP) that forms the basis for the development of the Respiratory Disease Phenotype Observatory has been finalized and core institutions have been identified.

## Launch of a Global Database on Breast Milk Intake

Human breast milk contains energy and nutrients that secure optimal infant growth, development and health. In order to monitor breastfeeding patterns and evaluate the effect of nutrition actions, it is vital to have reliable data. Currently, much of the available information on breastfeeding practices is in the form of self-reported data from mothers on the types of foods and liquids they feed their children and is collected mainly from small sample groups comprising around 30–100 mother-baby pairs. To accurately measure the amount of breast milk transferred from mother to infant and to assess whether an infant was exclusively breastfed, the deuterium oxide dose-to-mother (DTM) technique, a non-invasive stable isotope method, can be used.

In order to provide a unique and growing global collection of DTM data, the Agency created a database on breast milk intake by combining and harmonizing a large number of DTM studies. Aside from the obvious benefit of the larger sample size, which currently includes 3000 mother-infant pairs from 28 countries across all regions, the database generates more robust estimates of breast milk intake during infancy and helps to answer overarching research questions. It can be used, for example, to explore how socioeconomic status, the mother's body composition or the infant's gender influence breast milk intake around the world and over time. These new insights facilitate efforts to improve infant and young child feeding practices globally and help decision makers better understand potential barriers to and enablers for exclusive breastfeeding, and the importance of breast milk in the diets of infants beyond six months. The database is available for scientific purposes to both contributing researchers and those interested in accessing DTM data for secondary data analysis.



*The first edition of the global database on breast milk intake, in numbers.*

## Release of Audit Methodology for Medical Physics Clinical Training Programmes

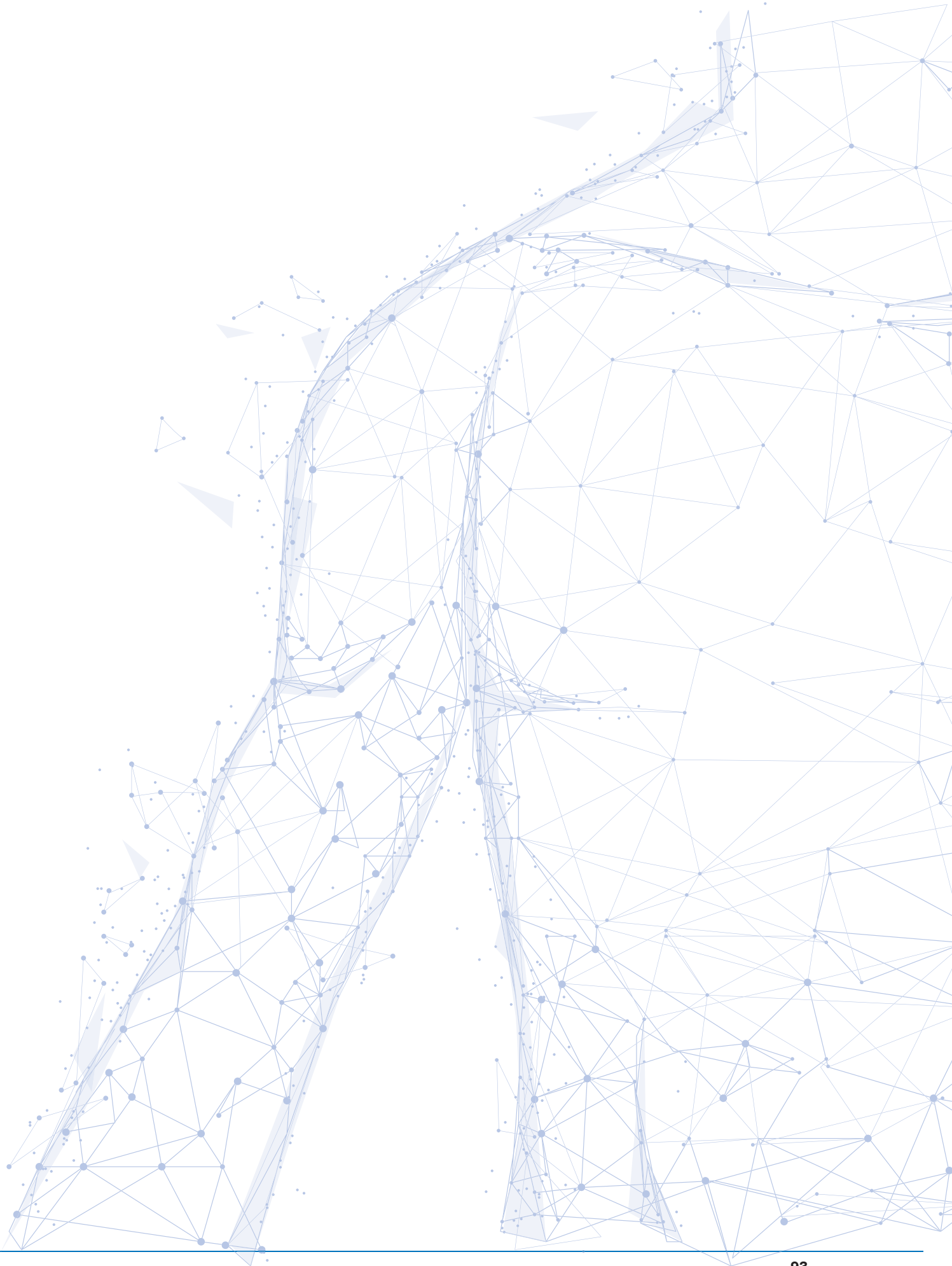
Formally structured clinical training is often overlooked when setting up educational programmes, which has a negative impact on the recognition of clinically qualified medical physicists. A structured and supervised clinical training programme is crucial to provide the competencies needed to work independently in one or more specialties of medical physics and achieve recognition as a clinically qualified professional.

In response to increasing demand from Member States wanting to establish and sustain high-quality clinical training programmes, the Agency released the *Audit Methodology for Medical Physics Clinical Training Programmes* (IAEA-TCS-74), which sets out a standardized methodology for auditing programmes in the area of medical physics. The publication is aimed at all professionals and medical residents involved in establishing, delivering or leading a clinical training programme in medical physics, and aims to clarify standards and manage expectations. Also, it highlights the major programme components that support the achievement of best practices in clinical training and can be used as a guide to establish related programmes. The audit methodology provides an independent review of a programme's compliance with relevant standards and its sustainability for quality improvement. It is structured in sequential phases, allowing for flexibility in its application and adoption in a variety of contexts and settings, and is applicable to all specialties of medical physics, including diagnostic radiology, nuclear medicine and radiation oncology, and all types of clinical training programme.

## New Services at the IAEA's Dosimetry Laboratory

The Agency enhances the capabilities of Member States to implement radiation imaging and treatment modalities safely and effectively through optimized dosimetry and medical physics practices. In 2022, the Agency updated dosimetry-related codes of practice, provided guidelines, conducted training events and developed educational material to support the medical physics profession and enhance quality and safety in radiation medicine. Through its Dosimetry Laboratory, the Agency expanded its support to Member States by introducing new services such as photon calibration and external beam radiotherapy audits, including the electron beam audit service – provided using the linear accelerator (linac) facility – and calibration of high dose rate brachytherapy sources. These services are essential to help Member States ensure that when ionizing radiation is used to treat cancer patients, the process is safe, accurate and effective and achieves optimal results.

For the first time since its commissioning at the Agency's Seibersdorf laboratories, the linac was used to provide training on: the practical aspects of its use in advanced radiotherapy techniques; the establishment of national dosimetry audits in radiotherapy; and updated guidance for Quality Assurance Team for Radiation Oncology (QUATRO) audits. In addition, the second edition of the QUATRO guidelines *Comprehensive Audits of Radiotherapy Practices: A Tool for Quality Improvement* was published to provide guidance on auditing new technologies in radiotherapy and to build on the knowledge of the audit teams by incorporating lessons learned from past audits and recommendations from QUATRO auditors.



## The Agency and WHO Help Benin Develop New National Cancer Control Plan

Every year in Benin, more than 6700 people are diagnosed with cancer and more than 4600 cancer patients die from the disease, according to the Global Cancer Observatory of the International Agency for Research on Cancer (IARC). To address the increasing number of cancer cases and the relatively low survival rates, the country's authorities, supported by the Agency and WHO, are making steady progress towards developing and implementing a comprehensive National Cancer Control Plan (NCCP). The Plan is aimed at reducing cancer morbidity and mortality by equipping facilities, training staff and deploying modern technology.

A technical team organized by Benin's National Programme for the Control of Non-Communicable Diseases has been working on a draft NCCP since the beginning of 2022. Under the Agency's flagship initiative Rays of Hope, Agency, IARC and WHO experts have helped the Beninese authorities identify objectives and priorities under the Plan. The Agency is also supporting the Ministry of Health in establishing the country's first radiotherapy and nuclear medicine services, to be hosted in the new Centre Hospitalier et Universitaire de Référence d'Abomey-Calavi. This support, provided within the framework of Rays of Hope, consists of the training of health professionals in radiation medicine, and the provision of certain equipment and expert advice.

"The Ministry of Health in Benin is committed to ongoing investments in cancer control, and the NCCP is a key strategic document to support these efforts", said Lamidhi Salami, President of the National Committee for Primary Health Care.

Benin officially launched the NCCP development process at a virtual workshop in August 2022. During the event, international experts from the Agency, the IARC and WHO discussed methodologies





for designing the NCCP and presented a draft situation analysis report examining the current state of cancer care in Benin. The report served as a reference for the Beninese technical experts, helping them produce a first draft of the Plan by the end of October 2022.

In December 2022, Benin's Ministry of Health, with the support of the Agency, WHO and other international experts, organized another workshop to review progress in developing the NCCP and validate the priorities and objectives defined. The participants identified specific activities for each of the Agency's ongoing cancer-related technical cooperation projects in Benin, establishing time-bound targets for project implementation.

"The NCCP will help align the technical cooperation among the different UN agencies providing cancer control support in the country, resulting in more efficient and equitable outcomes", said Souleymane Zan, WHO Representative to Benin.

The workshop participants also agreed that during the term of the NCCP (2023–2027), the new hospital would be inaugurated; a plan developed for human resources, including recruitment, training and deployment; and national programmes established for the prevention and early detection of cervical cancer, which causes the second highest number of cancer deaths among women after breast cancer.

According to the IARC's Global Cancer Observatory, the most diagnosed cancers in Benin in 2020 were prostate, breast, cervical, colorectal, liver and stomach cancer.

Benin is one of seven countries in Africa benefiting from the Rays of Hope initiative, which helps expand access to cancer diagnosis and treatment services in low and middle income countries. Globally, more than 50 countries have expressed interest in participating in Rays of Hope and, to date, a total of €37 million has been pledged for the initiative. Since Rays of Hope was launched in February 2022, it has helped mobilize resources to build, equip and sustain cancer care infrastructure and train specialists, health workers and technicians.



*Workshop launching Benin's comprehensive NCCP, attended by Agency, WHO and Beninese experts.*

# Water Resources

## **Objective**

*To support Member States applying isotope hydrology techniques for assessment and management of their freshwater resources, including hydroclimatic change impacts on water resources distribution and availability.*

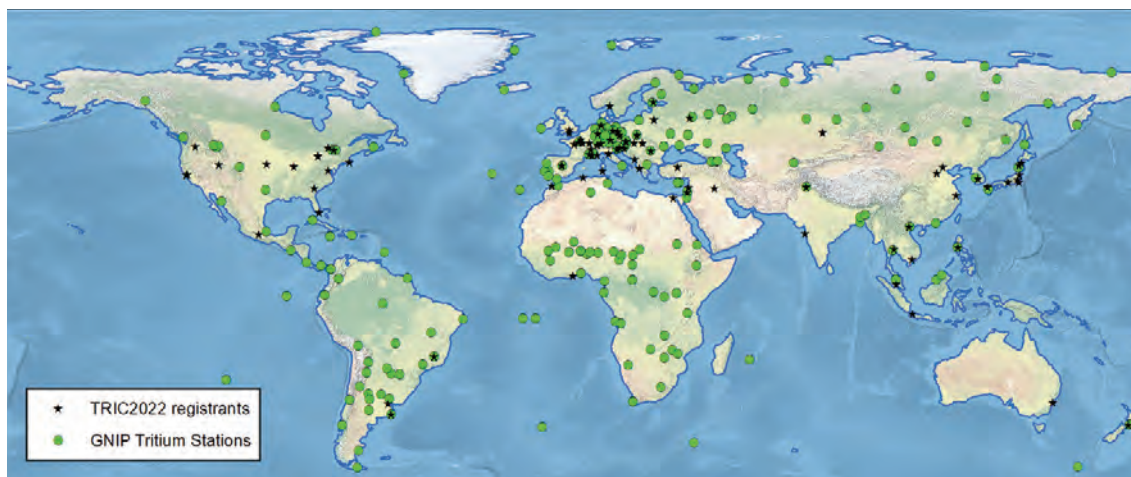
## **Addressing the Water Crisis**

Given the need for broad and dynamic collaboration to address the water crisis locally, regionally and globally, the Agency increased its engagement in global water-related activities and forums. During the 66th regular session of the General Conference, the Agency co-organized an event with the United Nations Educational, Scientific and Cultural Organization (UNESCO) on water security in a changing world, which highlighted how nuclear science can be used to make informed decisions on water preservation. At COP27, the Agency hosted four events in its #Atoms4Climate pavilion and contributed to three additional events with key partners (UNESCO, the World Meteorological Organization and the United Nations Environment Programme) in order to elevate discussions around water resources, security and adaptation and to highlight the role of nuclear and isotopic techniques in tackling a wide range of global water resource management issues, from protecting glaciers and wetlands to assessing groundwater in island States and the Sahel region.

At the regional level, the Agency supported the establishment of Djibouti's Regional Research Observatory on the Environment and Climate, inaugurated in October 2022. The Observatory will use isotope information to produce climate models and mapping tools in order to track the origins of air masses that bring rain, rates of groundwater replenishment and the movement of water through the hydrological cycle. Such information can be used by governments and aid agencies to assist in the management and prevention of water crises and other environmental crises.

## **Launch of New Isoscape Model**

The Agency's new Regionalized Cluster-based Water Isotope Prediction model of isoscapes for naturally occurring tritium in precipitation was published in 2022. The resulting maps depict the spatial distribution of present-day tritium in precipitation, following the dissipation of the thermonuclear emissions peak of the 1960s, by relating point-based isotopic information to climatic parameters to fill existing gaps. Such spatially contiguous information is a valuable baseline for the use of tritium as a natural tracer for waters of short residence time, which helps researchers and water professionals in Member States understand links between the atmosphere, surface water and groundwater systems.



*TRIC2022 registrants and GNIP tritium sampling locations in 2022.*

In 2022, the Agency compiled additional tritium data from Member States and made it available through the Global Network of Isotopes in Precipitation (GNIP) database. The Agency also assists in the quality control of tritium and other isotope analysis around the globe through training and interlaboratory comparison exercises. The Agency's 2022 Tritium Intercomparison (TRIC) exercise received 93 submissions from 80 laboratories in 40 Member States, an all-time record. Initial feedback has been sent to the participants and synthesis work will be carried out throughout 2023.

# Marine Environment

## Objective

*To support Member States to address and mitigate their most pressing marine challenges using nuclear and derived techniques while enhancing their expertise and capability to develop tailored science-based strategies for the sustainable management of marine ecosystems.*

## NUTEC Plastics: Marine Pollution and Impact Assessment

Plastic pollution is one of today's most pressing global environmental challenges and plastic debris is the most abundant type of pollution in the ocean; it can be found on shorelines, on the sea surface, in deep ocean trenches and in ocean sediments. Marine plastic debris can act as a reservoir for chemical contaminants that are either inherently present in plastic as manufacturing additives or taken up from the environment. Following exposure to the environment, plastic debris breaks down into microplastics, which are vectors for transmitting chemical contaminants into marine food webs. Isotopic techniques offer unparalleled precision and reliability in assessing the impact of plastic in the marine environment.

The downstream component of the Agency's Nuclear Technology for Controlling Plastic Pollution (NUTEC Plastics) initiative builds on the Agency's efforts to deal with plastic pollution through marine monitoring using isotopic tracing techniques. The IAEA Marine Environment Laboratories in



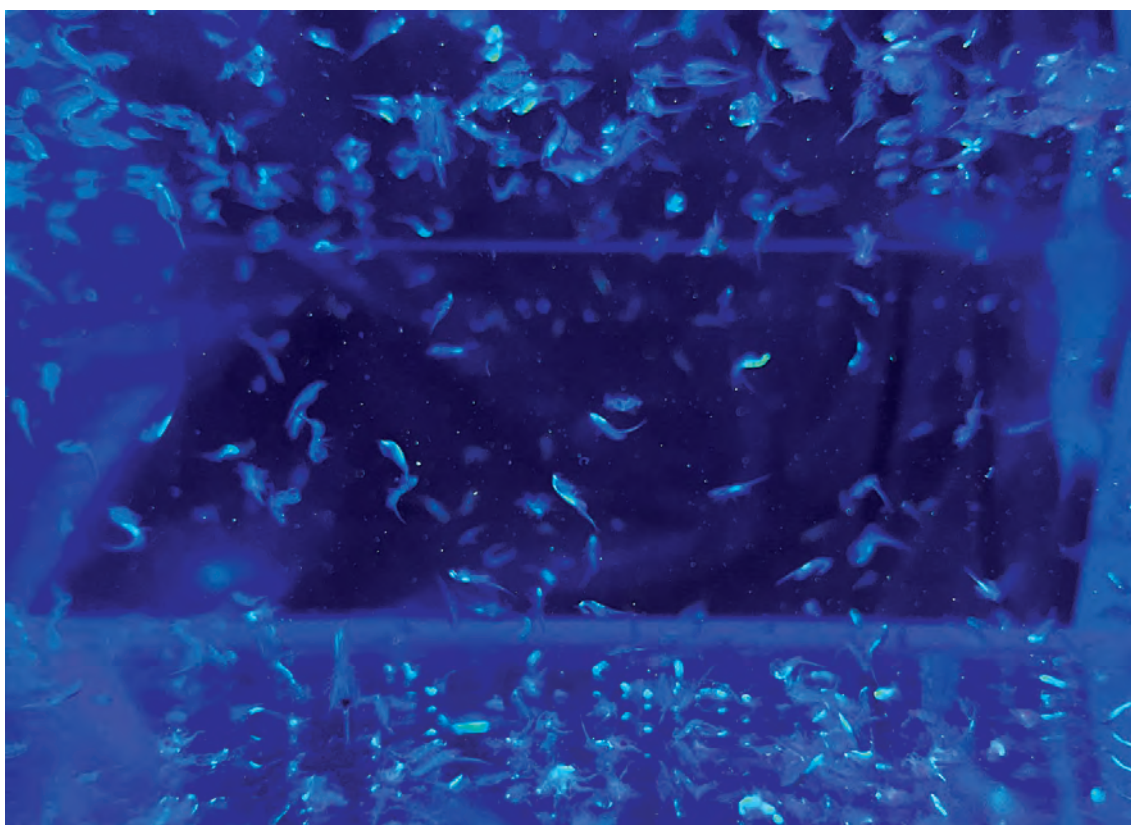
*The Director General delivers his opening remarks at a NUTEC side event at the 66th regular session of the Agency's General Conference, September 2022.*

Monaco — the only marine laboratories in the UN system — are central to NUTEC-related activities. In 2022, the laboratories enhanced their capability to characterize marine microplastics and their related in-house expertise in order to become a reference laboratory in marine plastic pollution monitoring for the NUTEC Plastics global monitoring network of specialized laboratories. To better monitor plastic pollution, significant progress has been made in harmonizing sampling and analysis protocols in collaboration with the Agency's Department of Technical Cooperation.

Experimental work was also conducted to look at biofilm growth on plastics; the transfer of pollutants to marine organisms via microplastics; the physiological effect of microplastics on marine organisms; and the development of new tools such as radioplastics and isotopically enriched nanoplastics.

As marine plastic debris can act as a reservoir for chemical contaminants, the Agency has developed methods for analysing plasticizers and flame retardants through the use of stable isotopes and mass spectrometric techniques to accurately measure these toxic contaminants in the marine environment. In 2022, these methods were used by the Agency, in collaboration with the Scientific Centre of Monaco, to demonstrate that plastic debris collected from shorelines around the Mediterranean Sea releases large amounts of chemicals. It was also demonstrated that leached chemicals accumulated in corals induce physiological stress on coral nubbins, and that these adverse effects are intensified by rising water temperatures. For Member States, these are valuable new insights into the effects of exposure to chemicals linked to plastic debris and ocean warming that will assist policymakers in their efforts to protect marine ecosystems.

In 2022, high-level discussions, side events at the Agency's General Conference and UN forums, and participation in scientific conferences were used as vehicles to raise awareness about NUTEC Plastics. For example, side events were organized at the UN Ocean Conference in Lisbon and the 7th annual Multi-stakeholder Forum on Science, Technology and Innovation for the SDGs to highlight the Agency's efforts to tackle marine plastic pollution on the global stage and emphasize the benefits of nuclear and isotopic techniques to advance knowledge of plastic pollution and its impacts.



*Fluorescent microplastics ingested by shrimps can be seen through translucent skin.*



*Coral nubbins grown in a laboratory environment for future use in studies on chemical impacts.*

## **Using Radionuclides to Assess the Potential of Blue Carbon as a Nature-Based Solution to Climate Change Worldwide**

Through the IAEA Marine Environment Laboratories, the Agency is involved in research projects with international research institutions in around 30 countries worldwide. Under these projects, eight peer-reviewed publications were issued in 2022 on the capacity of mangroves, seagrass meadows and salt marshes to sequester carbon in ocean sediments in Costa Rica, Denmark, Spain and the United Republic of Tanzania, among other countries. By using radiochemical separation, alpha spectrometry and gamma spectrometry to identify naturally-occurring isotopes in sediment cores, the Agency can determine the rate at which sediments — and therefore blue carbon — accumulate in a variety of marine and vegetated coastal ecosystems. Although more data is needed worldwide, blue carbon has provided the international community with a compelling case for taking action to preserve marine and coastal ecosystems to the greatest extent possible. At the 2022 UN Ocean Conference and COP27, the use of blue carbon as a nature-based solution to climate change was extensively discussed by experts, who highlighted the need for additional in-depth research and swift action to conserve these ecosystems.

## **Emergency Response Support to Peru to Assess the Impact of a Major Oil Spill on the Marine Environment**

Following an emergency request from the Government of Peru concerning a marine oil spill, considered to be the country's worst ever environmental disaster, Agency experts were dispatched on a fact-finding mission. Impact assessments of the oil spill on the marine environment of the Ventanilla coastline were made and a post-spill monitoring programme was designed in coordination with the Government of Peru. The expert mission visited laboratories involved in monitoring the coastal area to evaluate their capacity to conduct long-term monitoring and fingerprinting of petroleum hydrocarbons in environmental samples. To enhance the capabilities of these laboratories, equipment is being provided for the analysis of oil hydrocarbons from seawater, sediment and biota. This equipment includes freeze-dryers, microwave extraction systems, automated solvent evaporation systems, laser diffraction grain size analysers and a spectrofluorometer. Once the equipment has been delivered to Peru, Agency experts will travel to participating laboratories to train staff in its use and in methodology harmonization.

# Radiochemistry and Radiation Technology

## Objective

*To support Member States in strengthening their capability to produce radioisotopes and radiopharmaceuticals. To support Member States in applications of radiotracers and radiation technology for industrial and other uses, and in application of nuclear analytical techniques to address environmental challenges.*

## NUTEC Plastics: Innovative Technology for Upcycling

The upstream component of NUTEC Plastics builds on the Agency's efforts to deal with plastic pollution through recycling using radiation technology. In 2022, a technology readiness level (TRL) tool was developed to monitor and assess, in a consistent manner, Member States' progress in adopting radiation technology to tackle plastic pollution. In addition, an Excel-based economic assessment model was developed to assess the economic feasibility of introducing radiation technology into the national recycling process vis-à-vis conventional methods, and a guideline document was prepared on how to integrate electron beam technology in the recycling process. The guideline document, TRL tool and economic assessment tool were disseminated at an international workshop conducted at the Advanced Radiation Technology Institute, an Agency Collaborating Centre in the Republic of Korea.

In Asia and the Pacific, a regional training course was conducted in Indonesia in October on the steps required to advance along the TRL scale by developing pilot plastic waste recycling facilities that use irradiation. The training course was attended by 19 participants from 7 Member States. In addition, two national stakeholder meetings took place in Indonesia and Malaysia in October. Monthly one-to-one consultations with Indonesia, Malaysia, the Philippines and Thailand were organized to closely monitor progress and provide timely technical support. By December, the four countries had completed almost all TRL 3 requirements.

In Latin America, the first part of a regional training course on the modification of natural polymer waste using ionizing radiation was conducted virtually in September. The course covered a broad range of topics, from the fundamentals to applications, and was attended by 43 participants from 11 Member States. The hands-on part of the course was completed by 23 participants in late September in Argentina. Lastly, a regional training course on scaling up radiation technology was conducted in November in Brazil and was attended by 11 participants from 7 Member States.

In Africa, an expert mission was conducted in Ghana in May to review the national project plan with the relevant authorities and identify needs for successful involvement in NUTEC Plastics.

In the area of research, the first research coordination meeting under a coordinated research project on recycling plastic waste for structural and non-structural materials took place in April in Vienna with the participation of 18 Member States.





*Preparation of individual units of certified reference material IAEA-464 (radionuclides in brown rice).*

## Accreditation as Reference Material Producer

In 2022, the Agency was accredited by the Austrian National Accreditation Body to produce certified reference materials (CRMs) for activity concentrations of gamma ray-emitting radionuclides in selected environmental matrices. The accreditation process was fully documented using a quality management system and assessed by external experts, who provided an independent confirmation of technical competence in CRM production and compliance with ISO 17034:2016 requirements. To date, four materials have obtained CRM status within the scope of the accreditation, namely milk powder, two marine sediments, and brown rice. This work is of the utmost importance, as national laboratories use Agency CRMs to ensure the quality of their radioactivity measurement results.

## Launch of New IAEA/WHO Guideline

Novel radiopharmaceuticals are valuable tools used in the diagnosis and treatment of various diseases. For testing purposes in clinical trials, investigational radiopharmaceuticals are used. To minimize risks and ensure that the results of clinical trials are unaffected by inadequate safety, quality or efficacy arising from unsatisfactory production, investigational radiopharmaceuticals should be produced and managed using an effective quality management system and in accordance with good manufacturing practices. The new IAEA/WHO guideline on good manufacturing practices for investigational radiopharmaceutical products provides recommendations on the minimum standards that should be in place when preparing novel radiopharmaceuticals for phase I–III clinical investigations, including in relation to quality management, quality control and quality validation. It also gives detailed guidance on documentation, equipment, materials and production, among other things.

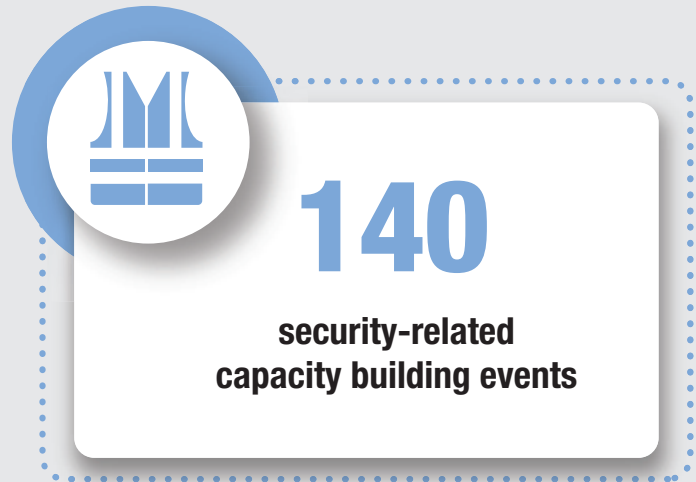
## Quality Assurance for Analysis of Environmental Samples

The Agency plays a leading role in producing and distributing reference materials that are used by Member States to obtain reliable stable isotope data. In 2022, the first ever training course on enhancing the quality of stable isotope ratio analysis was organized. The course focused on the types of reference material available, selection of the most appropriate reference materials for samples in analysis, definition of isotopic scale, optimal storage conditions, data elaboration and normalization for calculating high-quality stable isotope values. As part of the training, participants were taught how to use tailor-made calculating templates that were distributed at the end of the course and that may be used by national laboratories in their routine analytical work.

The background is a deep blue gradient with several glowing, multi-lined curves that sweep across the frame, creating a sense of motion and depth. The lines are composed of many thin, parallel strands, giving them a soft, ethereal appearance. The overall effect is clean, modern, and professional.

# **Nuclear Safety and Security**

# Nuclear Safety and Security



# 2022



**146** incidents reported

to the Incident and Trafficking Database



**18**

normative publications issued in 2022



**1**

IAEA Nuclear Security Series

**17**

IAEA Safety Standards Series

**Convention on Nuclear Safety**

**0** new Parties **91** total

**Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management**

**2** new Parties **88** total

**Convention on the Physical Protection of Nuclear Material**

**0** new Parties **164** total

**Amendment to the Convention on the Physical Protection of Nuclear Material**

**4** new Parties **131** total



# Incident and Emergency Preparedness and Response

## **Objective**

*To maintain and further enhance efficient Agency, national and international EPR [emergency preparedness and response] capabilities and arrangements for effective response to nuclear or radiological incidents and emergencies independent of the triggering event(s). To improve exchange of information on nuclear or radiological incidents and emergencies among Member States, international stakeholders, and the public and media in the preparedness stage of, and during response to, nuclear or radiological incidents and emergencies, independent of the triggering event(s).*

## **Strengthening Emergency Preparedness Arrangements**

The Agency continued developing two EPR Series publications that will help Member States implement effective EPR arrangements for responding to a severe accident at a nuclear power plant (NPP).

The Agency delivered several workshops on Arrangements for Notification, Reporting and Assistance in Nuclear or Radiological Incidents and Emergencies and on Emergency Preparedness and Response Arrangements for Effective Communication with the Public.

## **Response Arrangements with Member States**

The Agency held a Technical Meeting in Vienna in May 2022 to evaluate the Level 3 Convention Exercise hosted by the United Arab Emirates in 2021 and to consolidate the lessons identified. The host State, participating States and international organizations presented their evaluations of the exercise.

Actions to further increase transparency, promote the exchange of information, and improve the Member State Emergency Preparedness and Response Information Management System (EPRIMS) user experience were taken in 2022. These included refining the EPRIMS self-assessment modules and enhancing EPRIMS features and functions to better support the Emergency Preparedness Review peer review service and its reports.

## **Response to Events**

The Agency established a multilingual team operating 24/7 in order to maintain systematic contact with field teams in Ukraine and with the State Nuclear Regulatory Inspectorate of Ukraine, as well as to provide ad hoc technical assessments of developments with potential safety consequences. These events and their consequences are archived in a database that supports the Agency's analysis and its response.

The Agency arranged seven deliveries of nuclear safety- and security-related equipment to Ukraine, either donated by Member States or procured by the Agency with cash contributions from



*Full response mode exercise, September 2022.*

Member States. Eleven Member States offered equipment for donation to Ukraine; 12 Member States and one international organization offered extrabudgetary cash contributions to the Agency for assistance to Ukraine in the area of nuclear safety and security.

The Agency held 11 technical briefings for UN personnel serving in Ukraine as well as for staff of international organizations and permanent missions to the Agency on preparedness for a nuclear or radiological emergency in light of the situation in Ukraine.

In response to a request for assistance from Peru in 2022 regarding a patient who had developed severe skin lesions a few weeks after an interventional radiology procedure, the Agency coordinated an international assistance mission, involving the Response and Assistance Network (RANET) National Assistance Capabilities of France.

## **In-house Preparedness and Response**

The Agency maintained its 24/7 response capability in parallel with its response activities regarding the situation in Ukraine throughout 2022. The Agency trained staff on how to discharge emergency response roles and conducted two internal reduced-scope full response mode exercises as part of its training activities. The in-house training and exercise programme was evaluated by the Office of Internal Oversight Services in 2022, which found it to be relevant and instrumental in enabling the Agency to fulfil its emergency response roles.

# Safety of Nuclear Installations

## **Objective**

*To support Member States in improving the safety of nuclear installations during site evaluation, design, construction and operation through the availability and application of up-to-date safety standards. To support Member States in establishing and enhancing their national safety infrastructure through the conduct of safety review services and facilitation of adherence to, and implementation of, the CNS and the Code of Conduct on the Safety of Research Reactors. To support Member States in capacity building through human resource development, education and training, and knowledge management and knowledge networks by means of international cooperation, including exchange of information and operating experience, and coordination of research and development activities.*

## **Regulatory Infrastructure for Safety**

The Agency held four workshops on Self-Assessment of Regulatory Infrastructure for Safety, in India in February, in Poland in March, in the Czech Republic in May and in Egypt in October 2022.

The Agency signed Practical Arrangements that formalize cooperation in the area of education and training in radiation protection and safety with the Malaysian Nuclear Agency and the National Nuclear Energy Commission of Brazil in September 2022.

## **Convention on Nuclear Safety**

The Agency continued preparations for the Joint Eighth and Ninth Review Meeting of the Contracting Parties to the Convention on Nuclear Safety to be held in 2023. The Convention on Nuclear Safety Working Group met twice, in July and November 2022, to discuss proposals with a focus on contingency planning and business continuity, and other proposals aiming to improve the peer review process. An Officers' Meeting was held in July 2022 to discuss and agree, inter alia, on the updated templates for the Joint Eighth and Ninth Review Meeting.

## **Nuclear Harmonization and Standardization Initiative**

The regulatory track of the Nuclear Harmonization and Standardization Initiative (NHSI) aims to set up a flexible framework for collaboration that will help to harmonize the outcome of regulatory design reviews, enabling reactors of similar design to be built in different countries despite differences in their regulatory frameworks. The NHSI regulatory track consists of three complementary working groups:

Working Group 1 aims to develop pragmatic solutions for regulators to share the information they need to work together or learn from each other during design reviews. These solutions need to ensure that any information that is subject to special controls can be shared to meet the necessary requirements in all involved countries. Working Group 2 is looking at developing a joint international



review process that could be performed before the national licensing process is initiated, so as to enable any obstacles that would be a barrier to future licensing to be identified at an early stage. The advantage of such a joint international review process is that it would allow countries to use the outcomes of such reviews even if they were not involved in the review themselves. Finally, Working Group 3 is developing a process for regulators in one country to leverage regulatory reviews conducted in another country, as well as a process for regulators to work together in parallel while they undertake their national design reviews. This working group is also gathering lessons from current bilateral and multilateral collaboration during design reviews.

The results of the work of the three working groups and the processes developed will be presented in a number of publications that are under development.

### **IAEA SMR safety working group**

In order to coordinate the Agency's work in this area, the Agency has established a working group on safety of small and medium sized or modular reactors (SMRs). The purpose of the working group is to foster communication and ensure harmonization of the Agency's work on and developments in SMR safety, and to coordinate joint initiatives in support of Member States. The working group is focusing on communicating and coordinating Agency activities relating to SMR safety, with intra- and inter-Departmental interfaces taken into consideration; sharing insights from relevant developments at the Small Modular Reactor Regulators' Forum, the International Nuclear Safety Advisory Group and industry forums on safety considerations for SMRs; developing and implementing a work plan for 2021–2026 to enhance the safety of evolutionary and innovative reactors, including SMRs; and maintaining oversight of the application of the Agency safety standards to evolutionary and innovative reactors, including SMRs.

A key deliverable of the working group in 2022 was the publication of Safety Reports Series No. 123 on *Applicability of Safety Standards to Non-Water-Cooled Reactors and Small Modular Reactors* (available on the IAEA Preprint Repository). This Safety Report was developed with input from experts in technology and safety standards from 30 Member States and several international organizations, including representatives of regulatory bodies and the Small Modular Reactor Regulators' Forum. On the basis of the findings in the Safety Report, the working group has developed a programme of work with an oversight mechanism to ensure that safety issues relevant for non-water-cooled reactors and SMRs are properly considered during the review, update and development of safety standards. The programme also anticipates the development of other Agency publications (e.g. Safety Reports or IAEA Technical Documents) to capture lessons learned from the operation of non-water-cooled reactors and SMRs, and from other stages in their life cycle, with regard to how requirements and recommendations from safety standards are implemented.

In particular with regard to practices in areas where knowledge is continuing to evolve, the working group continues to coordinate Agency efforts to provide Member States with a suitable forum and a repository of technology-specific knowledge on SMR safety. In 2022, the working group coordinated the implementation of four webinars on SMR safety. In October 2022, a video was commissioned to better inform interested parties, including the general public, about the Agency's role in assisting Member States to address the challenges that innovative reactors and SMRs may present.

### **Design Safety and Safety Assessment**

A Technical Meeting on Experiences in Using Probabilistic Safety Assessment in the Design of Nuclear Power Plants was held in Vienna in April 2022, to share experiences of the development of probabilistic safety assessment (PSA) models. The PSA models could be instrumental in supporting the use of PSA for justification and optimization of design safety for innovative technologies, including those used for SMRs.

The Agency held a Technical Meeting on the Software Reliability of Digital Instrumentation and Control Systems for Nuclear Power Plant Safety in Vienna in December 2022, to share Member States' experiences, approaches and challenges.

The Agency conducted Technical Safety Reviews of new-build projects and operating plants, helping Member States to enhance the nuclear safety justification in areas potentially in need of improvements in accordance with Agency safety standards: for Koeberg NPP in South Africa in October 2021–May 2022 and for Laguna Verde NPP in Mexico in March–November 2022.

## Safety and Protection against External Hazards

The Agency published *Seismic Hazards in Site Evaluation for Nuclear Installations* (IAEA Safety Standards Series No. SSG-9 (Rev. 1)) in January 2022.

A Technical Meeting on the Effects of Climate Change on Meteorological and Hydrological Hazards for Nuclear Installations was held in November 2022. The meeting addressed the main concerns of the nuclear safety community in relation to hazards resulting from climate change and focused on identifying the best available methods for assessing site-specific hazards and on providing input and guidance to the Agency for developing technical documents.

A Technical Meeting on the Optimization of Protection of Advanced Reactors Against External Hazards was held in November–December 2022. The meeting reviewed the application of a risk informed and performance based approach to the optimization of protection for advanced reactors with advanced safety features.

The Agency continued to provide Site and External Events Design reviews, reviewing the site selection process and design safety in relation to external events: at Dukovany and Temelín NPPs (Czech Republic) in May 2022 and at Doicești (Romania), focusing on SMR siting, in August 2022. A large number of capacity-building events on regulatory review of the site-related chapters of the safety analysis report were organized for embarking countries.



OSART mission to Saeul NPP, Republic of Korea, October–November 2022.

## Operational Safety of Nuclear Power Plants

Nine meetings were held in 2022 to supplement and improve the database of ageing management practices publicly available on the Agency's International Generic Ageing Lessons Learned website.

Five Operational Safety Review Team (OSART) missions, including follow-up missions, were successfully completed in 2022 in France, the Islamic Republic of Iran, the Republic of Korea and the United Arab Emirates. The revised OSART guidelines for NPPs and nuclear corporate organizations were published in 2022.

The Agency conducted a support mission based on the new Peer Review of Operational Safety Performance Experience methodology in Argentina in December 2022 to enhance Argentina's operational safety performance improvement programme.

The Agency conducted the first Independent Safety Culture Assessment mission, to Brazil in October 2022, and a Safety Culture Continuous Improvement Process service in Poland in November 2022.

## Safety of Research Reactors and Fuel Cycle Facilities

In cooperation with the OECD/NEA, the Agency organized a Technical Meeting for the National Coordinators of the Joint IAEA–OECD/NEA Fuel Incident Notification and Analysis System (FINAS) in Paris in September 2022 to exchange information on incidents submitted to the FINAS database.

The Agency held a Technical Meeting on the Safety of Fuel Manufacturing for Advanced Reactors in Vienna in November 2022, where participants discussed safety aspects of manufacturing fuels for advanced reactors, including for small modular reactors.

The Agency published *Safety Assessment for Research Reactors and Preparation of the Safety Analysis Report* (IAEA Safety Standards Series No. SSG-20 (Rev. 1)) in August 2022.

The Agency held a Technical Meeting on the Periodic Safety Review of Nuclear Fuel Cycle Facilities in Vienna in June 2022 to discuss and exchange national experience regarding the periodic safety review of nuclear fuel cycle facilities.



## Launch of Notification System to Protect Nuclear Installations from Natural Disasters

From earthquakes to floods and volcanic eruptions, natural disasters can occur very suddenly and can pose a serious challenge to the safety of nuclear installations and facilities. To be sufficiently prepared for such events, in 2022 the Agency launched the External Events Notification System (EENS) – a digital tool to help predict the severity of natural hazards and assess their effects on the safe operation and maintenance of nuclear facilities.

The EENS provides real-time information on disasters – including earthquakes, volcanic eruptions, wildfires, tsunamis, hurricanes and floods – that have taken place or are predicted to happen. Designed to provide initial assessments of the severity of external events on nuclear facilities, which the Agency's Incident and Emergency Centre (IEC) uses to take action as needed, the system collects data on the location and scale of the hazardous event, effectively assessing the potential impact on nuclear installations and major population centres. It then sends the data to the IEC and the Agency's External Events Safety Section (EESS) within 30 minutes, enabling an appropriate and timely response.

The EENS was developed in cooperation with the Pacific Disaster Center (University of Hawai i) and internet application developer Tenefit. It involved adapting the Center's DisasterAWARE platform specifically to the Agency's goals of ensuring the safety of all nuclear installations where radioactive material may be affected by the hazard. Its creation aims to help countries prevent, mitigate and manage the risks of extreme weather events, which are increasing in many regions of the globe as climate change accelerates.

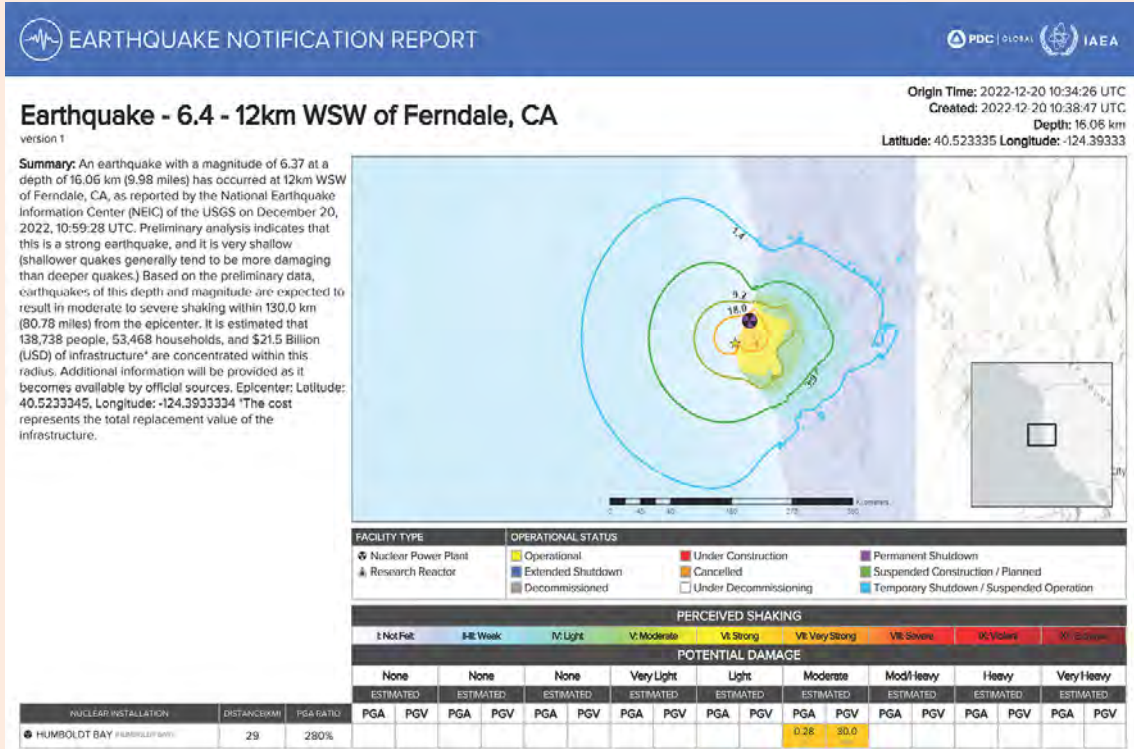
"This tool helps us to promptly identify natural hazards that can affect nuclear or radiation safety in order to exchange information and to coordinate international assistance between Member States," said IEC Response System Officer Günther Winkler.

The EENS consists of two components: the Alert System and the External Event Damage Forecast. The Alert System monitors the situation around a nuclear facility in real time and warns the Agency of any hazard that could affect it. The External Event Damage Forecast receives information from the Alert System and creates an initial estimate of potential damage to the nuclear facility and its impact on populated areas. This estimate contains basic information about the event, including its magnitude, time, location and anticipated impacts.

In the event of a hurricane, for example, it would include basic information on the hurricane with maps, expected storm surge at coastal sites, possible arrival time and estimated wind speed at nuclear installation sites. "This information is vital for the IEC to be able to swiftly offer its assistance to support an affected country," said Paolo Contri, Head of the Agency's EESS.

The system has been in operation since August 2022, providing real-time monitoring of all external events affecting nuclear installations worldwide and helping to alert the IEC with a view to the potential provision of its services in the event of major damage. An analysis of lessons learned, on the basis of all available information, is already in progress.

The system was appreciated by many stakeholders at a dedicated side event during the 66th regular session of the General Conference in Vienna and at the EESS annual donors' meeting held in October 2022, where the main funding organizations – Électricité de France (France), the Nuclear Regulation Authority (Japan) and the Department of State (United States of America) – welcomed the new tool and funded additional extensions to cover other types of events. In particular, Member States welcomed the systematic approach to analysing lessons learned with regard to near misses made possible by the EENS. The analysis of near misses, as opposed to analysing only accidents, represents a much more proactive mindset towards developing a generic approach to the assessment of plants' ability to withstand rare and unanticipated events of all types.



EENS earthquake notification report for an earthquake that occurred off the west coast of the United States of America.

# Radiation and Transport Safety

## **Objective**

*To support Member States in improving radiation safety of people and the environment through the development of safety standards and by providing for their application. To support Member States in establishing the appropriate safety infrastructure through support and implementation of the Code of Conduct on the Safety and Security of Radioactive Sources and its supplementary guidance, as well as through safety reviews and advisory services. To support Member States in capacity building through education and training, and in encouraging the exchange of information and experience.*

## **Radiation Safety and Monitoring**

The Agency hosted a Technical Meeting on Establishing Efficient Regulatory Control for Protection Against Radon in Workplaces in Vienna in April 2022 to discuss protection against radon in different exposure situations, with particular focus on combined sources of exposure and enforcement of regulatory control. The input provided will be considered for the development of the draft Safety Guide on *Protection of Workers Against Exposure Due to Radon*.

The Agency worked with the International Commission on Radiological Protection (ICRP) in reviewing the fitness for purpose of the current system of radiological protection. A joint topical session with the ICRP was hosted by the Agency during the Radiation Safety Standards Committee meeting in June 2022, where the Agency presented feedback from the application of safety standards.

The Agency held a virtual Technical Meeting on Radiation Protection in Fluoroscopically Guided Interventional Procedures in March 2022, to review existing guidance and resources for the prevention and management of unintended medical exposures in fluoroscopically guided interventional procedures; to evaluate the status of the Safety in Radiological Procedures reporting system; and to review new aspects of occupational radiation protection in fluoroscopically guided interventional procedures.

The Agency conducted a mission to Estonia in March 2022 to assess practical aspects of radiation protection in medicine, comparing national practices to the requirements set out in GSR Part 3 and the recommendations provided in *Radiation Protection and Safety in Medical Uses of Ionizing Radiation* (IAEA Safety Standards Series No. SSG-46).

The Agency published *Radiation Protection in Dental Radiology* (Safety Reports Series No. 108) in May 2022 and released e-learning modules on radiation protection in this area, helping dental professionals understand how to properly choose the right X-ray examination and to optimally use X-ray equipment features in order to keep exposure of the patient and dental staff low.

## Regulatory Infrastructure

The Agency held two Workshops on the Development of Regulatory Infrastructure for Radiation Safety and Security of Radioactive Material in Vienna in April 2022 — one for the Caribbean region and one for Africa — and another in June 2022 for Latin America and the Caribbean, to review and discuss regulatory responsibilities concerning the control of radiation sources and the need to establish and enhance national regulatory infrastructure.

## Transport Safety

The Agency published three Specific Safety Guides on the safe transport of radioactive material. Based on a review of proposed changes to the *Regulations for the Safe Transport of Radioactive Material* (2018 Edition) (IAEA Safety Standards Series No. SSR-6 (Rev. 1)), the Transport Safety Standards Committee decided to launch a revision of this publication.

The Agency established a working group on transportable NPPs and initiated development of a position paper on the terminology, design and applicability of existing transport safety standards.

A virtual meeting was held with representation from the Agency, the International Civil Aviation Organization, the International Maritime Organization, the United Nations Economic Commission for Europe and the Universal Postal Union in October 2022 to discuss the review and revision processes for the publications of these international organizations and to determine whether a faster and more flexible review and revision process could be developed for the *Regulations for the Safe Transport of Radioactive Material*.

## Radiation Safety Technical Services

The Radiation Safety Technical Services Laboratory (RSTS Laboratory) continued to provide the highest quality of service for Agency staff. For the 16th year in a row, the Agency's RSTS Laboratory received recognition of the excellence of its radiation monitoring by means of ISO/IEC 17025:2017 accreditation.



Radiation monitoring measurements are taken at different workplaces at the Seibersdorf laboratories by the staff of the RSTS Laboratory.



# Radioactive Waste Management and Environmental Safety

## Objective

*To support Member States in improving the safety of radioactive waste and spent fuel management, including geological repositories for high level waste, decommissioning, remediation and environmental releases, through the development of safety standards and providing for their application. To support Member States in improving the safety of radioactive waste and spent fuel management, including geological repositories for high level waste, decommissioning, remediation and environmental releases through peer reviews and advisory services; and to assist in their adherence to, and facilitate the implementation of, the Joint Convention. To support Member States in capacity building through education and training and by encouraging the exchange of information and experience.*

## Radioactive Waste and Spent Fuel Management

The Agency developed guidance on the conduct of Integrated Regulatory Review Service (IRRS) and Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) missions in a back-to-back manner. This guidance was used for the first time in Slovenia, where an IRRS mission held in April 2022 was followed by an ARTEMIS



*Back-to-back IRRS–ARTEMIS mission to Finland, October 2022 — ONKALO deep geological disposal facility.*

mission in May 2022. An IRRS-ARTEMIS back-to-back mission was also conducted in Finland in October 2022, and back-to-back missions started in Slovakia in September and Sweden in November 2022, to continue in 2023.

The Agency published *Leadership, Management and Culture for Safety in Radioactive Waste Management* (IAEA Safety Standards Series No. GSG-16) in January 2022.

The Agency held a virtual Technical Meeting on Guidance on Preparing for and Conducting Regulatory Reviews and Assessments of Geological Disposal Programmes in April 2022, and a Technical Meeting on Proportionate Regulation and Licensing of Different Types of Radioactive Waste Disposal Facilities, in Vienna in May 2022.

## Assessment and Management of Environmental Releases

The Advanced Liquid Processing System (ALPS) Task Force reviewed documents and data such as the radiological environmental impact assessment produced by the Tokyo Electric Power Company (TEPCO). These data are used by the Government of Japan and TEPCO in their assessment and management of environmental releases. The Task Force's review was a part of the broader safety review by the Agency looking at all aspects of the planned discharge of ALPS treated water against relevant Agency safety standards. The three major components of this safety review included the assessment of protection and safety; regulatory activities and processes; and independent sampling, data corroboration, and analysis.

The Agency held the Second Technical Meeting on Methods for Radiological and Environmental Impact Assessment (MEREIA) in Vienna in November–December 2022. The MEREIA programme is designed to enhance capacity in Member States for evaluating and addressing the impact of radioactivity in the environment. In addition, a series of webinars was held throughout 2022 for the development of young professionals as part of the capacity building and knowledge management objectives of MEREIA.

A new Database on Discharges of Radionuclides to the Atmosphere and Aquatic Environment was developed in 2022 to visualize discharge data. A Technical Meeting with Member States was held in April 2022 to agree on the scope and content of the database and the discharge data to be collected.

## Decommissioning and Remediation Safety

The Agency published *Remediation Strategy and Process for Areas Affected by Past Activities or Events* (IAEA Safety Standards Series No. GSG-15) in May 2022.

The Agency held the Fifth Technical Meeting on the International Project on Decommissioning of Small Medical, Industrial and Research Facilities in Brussels in May 2022, to advance the exchange of experiences and lessons learned related to the decommissioning of small facilities.

The Agency held the Annual Meeting of the Coordination Group for Uranium Legacy Sites virtually in May 2022 to continue the exchange of information among and technical coordination activities of Member States and international organizations involved in remediation of legacy uranium sites.

The Agency held the Annual Meeting of the Regulatory Forum for Safety of Uranium Production and Naturally Occurring Radioactive Materials in a virtual manner in June 2022. The participants discussed the progress made on high priority activities since the 2021 annual meeting of this body.

The Agency held a Technical Meeting of the International Working Forum on Regulatory Supervision of Legacy Sites on Long-Term Post-Remediation Management in Vienna in October 2022, focusing on areas affected by past activities or events. In November 2022, a Joint Workshop of the International Working Forum on Regulatory Supervision of Legacy Sites and the Coordination Group for Uranium Legacy Sites on Challenges to Remediation and Regulatory Supervision of Legacy Sites was held in Centurion, South Africa.



*Site visit to Tudor Shaft dump and Lancaster Dam in Krugersdorp, South Africa, November 2022.*

## Joint Convention

The Fourth Extraordinary Meeting of the Contracting Parties to the Joint Convention was held in Vienna in May 2022 to discuss potential ways to improve procedural mechanisms of the Joint Convention, taking into account the growing number of Contracting Parties and with a view to identifying and eliminating technical discrepancies between existing guidance documents of the Joint Convention.

The Agency hosted and provided Secretariat support for the Seventh Review Meeting of the Contracting Parties to the Joint Convention held in Vienna in June–July 2022. At the meeting, Contracting Parties reviewed and discussed National Reports and agreed, inter alia, on the progress made since the Sixth Review Meeting; several Good Practices and Areas of Good Performance, overarching issues and Suggestions; and the dates for the Eighth Review Meeting, i.e. 17 to 28 March 2025.

# Nuclear Security

## Objective

*To promote adherence to relevant legally and non-legally binding international instruments to enhance nuclear security globally. To assist States in establishing, maintaining and sustaining national nuclear security regimes for nuclear and other radioactive materials, including during transport, and associated facilities used for peaceful purposes. To play the central role of facilitating and enhancing international cooperation and increasing visibility and awareness through communication on nuclear security.*

## The Convention on the Physical Protection of Nuclear Material and its Amendment

The Agency continued encouraging universal adherence to and effective implementation of the Convention on the Physical Protection of Nuclear Material (CPPNM) and its Amendment (A/CPPNM) and provided technical and legislative assistance in this regard, upon request. An additional four States adhered to the A/CPPNM in 2022.



*The first Conference of the Parties to the Amendment to the Convention on the Physical Protection of Nuclear Material was held in Vienna from 28 March to 1 April 2022.*

## Nuclear Security Guidance

One new publication in the IAEA Nuclear Security Series (NSS) was issued in 2022, bringing the total number of publications in the NSS to 43. In addition, 2 draft guidance publications were approved for publication, and 15 others, including 4 revisions of existing publications, were at various stages of development during 2022. In total, 32 NSS publications are now available in Arabic, French, Russian and Spanish, including all NSS publications at the level of Nuclear Security Fundamentals, Recommendations and Implementing Guides.

## Needs Assessment and Capacity Building

The Agency conducted 18 Integrated Nuclear Security Support Plan (INSSP) missions, 3 INSSP finalization missions, 8 awareness-raising missions targeting decision makers, and 1 INSSP preparatory mission in 2022. The total number of States with approved INSSPs remained at 92.

The Agency conducted 140 training activities on nuclear security topics, including 17 webinars, for more than 4000 participants from 154 States. The Agency held four Schools on Nuclear Security, including one for Marie Skłodowska-Curie Fellowship Programme fellows that was attended by 68 participants from 46 States. The first national School on Nuclear Security conducted in Portuguese took place in 2022, implemented in cooperation with the Government of Brazil through the Nuclear and Energy Research Institute.

Two new Member State institutions were designated as Collaborating Centres in different areas of nuclear security in 2022, for a total of ten such Collaborating Centres. Twenty-four training-related Agency events in nuclear security were hosted by Collaborating Centres.

## Information and Computer Security

In 2022, the Agency conducted 45 computer security-related events, with the majority focusing on national-level support for computer security regulations/inspections and computer security exercises. The Agency also continued preparing for the International Conference on Computer Security in the Nuclear World: Security for Safety, planned to be held in June 2023.

## Risk Reduction

During 2022, 33 States benefited from comprehensive assistance to ensure the safe and secure management of high activity disused radioactive sources, including their repatriation or removal to authorized recipients.

The Agency assisted two Member States with physical protection upgrades at nuclear facilities. The Agency also assisted one Member State with a transportation security upgrade. These upgrades were complemented by specialized technical training to support the operation, maintenance and sustainability of physical protection equipment, systems and measures for detection, delay and response.

## Major Public Events

The Agency provided support for nine major public events in eight Member States in 2022, including the FIFA World Cup 2022 in Qatar and COP27 in Egypt. The Agency also loaned 911 items of radiation detection equipment.



*Mobile-Integrated Nuclear Security Network training for the implementation of nuclear security measures at COP27 in Egypt, November 2022.*

## Incident and Trafficking Database

In 2022, States reported 146 incidents to the Incident and Trafficking Database. Five of the reported incidents related to trafficking, three of which involved scams (including attempted scams). There were 23 reported incidents in which intent to engage in trafficking or malicious use could not be determined. There were also 118 reported incidents in which material was out of regulatory control but that were unrelated to trafficking, malicious use or scams.

## Nuclear Security Fund

From 1 January to 31 December 2022, the Agency received contributions to the Nuclear Security Fund from 12 Member States and other donors. The total revenue<sup>1</sup> in 2022 was €29 million. In implementing activities in 2022, the Agency utilized funds from contributions received in 2022 as well as from previous contributions, notably those received in 2021 from 15 Member States. The Agency also used funds received in earlier years, including those contributed by the European Union.

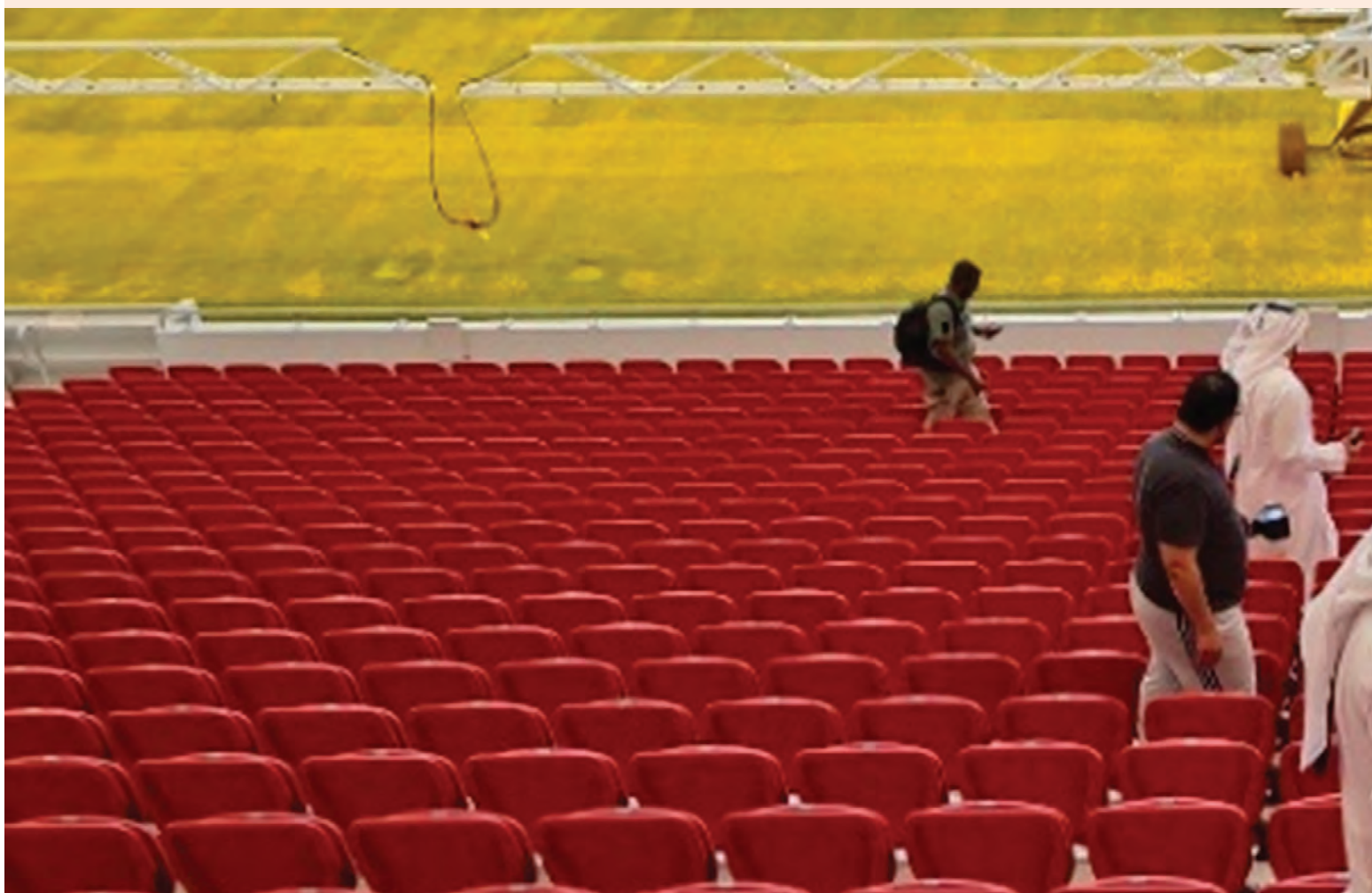
<sup>1</sup> For the purposes of this report, 'revenue' refers to funds that have been recognized as revenue or deferred revenue in accordance with the International Public Sector Accounting Standards.

## Supporting Nuclear Security at the FIFA Men's World Cup 2022 in Qatar

The organization of a major public event, such as a sporting event or high-level political meeting, presents unique security challenges, including possible threats involving nuclear or other radioactive material. In the run-up to the FIFA Men's World Cup held in Qatar at the end of 2022, the Agency helped the country to integrate nuclear security measures into its overall security plans for that large-scale event. With over 1.4 million people visiting the country during the World Cup, ensuring the optimum prevention and security measures to guard against the potential use of nuclear or other radioactive material in a criminal or terrorist act was of crucial importance to protecting people and the environment.

Working with Qatar's National Committee for the Prohibition of Weapons (NCPW) throughout 2022, the Agency and international experts provided comprehensive training to national counterparts on developing and implementing nuclear security measures and on responding to nuclear security events and related emergencies. The Agency organized two national workshops to enhance participants' awareness and understanding of the planning and execution of nuclear security measures for major public events. Additionally, representatives from different ministries and governmental authorities responsible for the secure planning of major public events were also trained in responding to criminal or intentional unauthorized acts involving nuclear or other radioactive material. In total, around 50 participants were trained in preparation for the World Cup.

"The Agency's experience in supporting nuclear security measures at major public events was adapted to Qatar's needs," said Elena Buglova, Director of the Division of Nuclear Security. "During



the training sessions, a team of experts worked with national authorities. Through scenario-based group discussions, hands-on activities and practical field exercises, participants learned to operate radiation detection equipment and implement the standard operating procedures developed to support countries organizing major public events.”

As part of its technical support, the Agency loaned over 120 radiation detection instruments – including personal radiation detectors, radionuclide identification devices and portable backpack-type detectors – to Qatar. These were used by the trained governmental authority staff in stadiums and other strategic locations.

“For the first time, the world’s biggest football tournament was held in the Middle East, and it was the first FIFA World Cup where the stadiums were so intricately linked, and they welcomed crowds of fans at the same time,” said Rashid Al-Nuaimi, Acting Chairman of the NCPW. “This safety and security challenge led the NCPW to turn to the IAEA for assistance. We are looking forward to future cooperation and support, especially in nuclear security systems and measures.”

The Agency regularly provides nuclear security support to Member States for major public events, building on two decades of experience starting with support for Greece in connection with nuclear security arrangements for the Athens Olympic Games in 2004. By the end of 2022, the Agency had worked with 43 countries to counteract potential nuclear security threats.

*The Agency provided Qatar with equipment and training to support the country’s efforts to strengthen nuclear security measures in preparation for the FIFA Men’s World Cup 2022.*





The background is a deep blue gradient with several glowing, multi-lined curves that sweep across the frame, creating a sense of motion and depth. The lines are composed of many thin, parallel strands, giving them a ribbon-like appearance. The overall effect is clean, modern, and technical.

# **Nuclear Verification**

# Nuclear Verification



**189**

**States\* with safeguards agreements in force of which**

**140** States had additional protocols in force



**2975**

**verification activities undertaken**



**1 353**

**nuclear facilities and locations outside facilities under safeguards**



**230 754**

**significant quantities of nuclear material under safeguards**



**14 066**

**days of in-field verification**



**271**

**days spent in quarantine**

\* The designation employed does not imply the expression of any opinion whatsoever concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

# 2022

## Conclusions\*\*

**74  
States**

**all nuclear material  
remained in  
peaceful activities**

**106  
States**

**declared nuclear material  
remained in  
peaceful activities**



**3  
States**

**nuclear material, facilities  
or other items to which  
safeguards had been  
applied remained in  
peaceful activities**

**5  
States**

**nuclear material in selected  
facilities to which  
safeguards had been  
applied remained in  
peaceful activities**

\*\* These States do not include the Democratic People's Republic of Korea (DPRK), where the Agency did not implement safeguards and, therefore, could not draw any conclusion.

# Nuclear Verification<sup>1,2</sup>

## Objective

*To deter the proliferation of nuclear weapons by detecting early the misuse of nuclear material or technology and by providing credible assurances that States are honouring their safeguards obligations, and, in accordance with the Agency's Statute, assist with other verification tasks, including in connection with nuclear disarmament or arms control agreements, as requested by States and approved by the Board of Governors.*

## Implementation of Safeguards in 2022

Over the course of 2022, the impact of the COVID-19 pandemic on safeguards implementation diminished markedly. The Agency carried out 3000 verification activities (3000 in 2021) and spent 14 100 days in the field conducting those activities (14 600 in 2021). This ensured that the Agency was able to draw soundly based conclusions for all States for which safeguards were implemented by the Agency for 2022.

At the end of the year, the Agency drew a safeguards conclusion for each State for which safeguards were applied in 2022. This conclusion was based on an evaluation of all safeguards relevant information available to the Agency in exercising its rights and fulfilling its safeguards obligations for 2022.<sup>3</sup>

In 2022, safeguards were applied for 188 States<sup>4,5</sup> with safeguards agreements in force with the Agency. Of the 134 States that had both a comprehensive safeguards agreement (CSA) and an additional protocol (AP) in force, the Agency drew the broader conclusion that *all* nuclear material remained in peaceful activities for 74 States<sup>6</sup>; for the remaining 60 States, as the necessary evaluation regarding the absence of undeclared nuclear material and activities for each of these States remained ongoing, the Agency concluded only that *declared* nuclear material remained in

<sup>1</sup> The designations employed and the presentation of material in this section, including the numbers cited, do not imply the expression of any opinion whatsoever on the part of the Agency or its Member States concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

<sup>2</sup> The referenced number of State Parties to the Treaty on the Non-Proliferation of Nuclear Weapons is based on the number of instruments of ratification, accession or succession that have been deposited.

<sup>3</sup> For States with a comprehensive safeguards agreement (CSA) in force with an operative small quantities protocol (SQP) based on the original standard text, the Agency's ability to draw a credible and soundly-based annual safeguards conclusion is significantly affected. This is due, *inter alia*, to the fact that the original standard text of the SQP holds in abeyance the requirement for these States to provide to the Agency an initial report on all nuclear material as well as the Agency's right to perform verification activities in these States. In light of such limitations, and given the significant lapse of time since the decision of the Board of Governors in 2005 authorizing the Director General to conclude with each State with an SQP an exchange of letters giving effect to the revised standardized text and the modified criteria, the Agency may no longer be able to draw a safeguards conclusion for such States unless the States concerned respond positively to the repeated calls by the Director General to amend or rescind such SQPs.

<sup>4</sup> These States do not include the Democratic People's Republic of Korea (DPRK), where the Agency did not implement safeguards and, therefore, could not draw any conclusion.

<sup>5</sup> And Taiwan, China.

<sup>6</sup> And Taiwan, China.



*Two inspectors demonstrate environmental sampling techniques.*

peaceful activities. Similarly, for the 46 States with a CSA but with no AP in force, the Agency concluded only that *declared* nuclear material remained in peaceful activities.

For those States for which the broader conclusion has been drawn, the Agency is able to implement integrated safeguards: an optimized combination of measures available under CSAs and APs to maximize effectiveness and efficiency in fulfilling the Agency's safeguards obligations. Integrated safeguards were implemented for the whole of 2022 for 69 States<sup>7,8</sup>.

Safeguards were also implemented with regard to nuclear material in selected facilities in the five nuclear-weapon States Parties to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) under their respective voluntary offer agreements. For these five States, the Agency concluded that nuclear material in the selected facilities to which safeguards had been applied remained in peaceful activities or had been withdrawn from safeguards as provided for in the agreements.

For three States not party to the NPT, the Agency implemented safeguards pursuant to item-specific safeguards agreements based on INFCIRC/66/Rev.2. For these States, the Agency concluded that nuclear material, facilities or other items to which safeguards had been applied remained in peaceful activities.

As of 31 December 2022, five States Parties to the NPT had yet to bring CSAs into force pursuant to Article III of the Treaty. For these States Parties, the Agency could not draw any safeguards conclusions.

### **Conclusion of safeguards agreements and APs, and amendment and rescission of small quantities protocols**

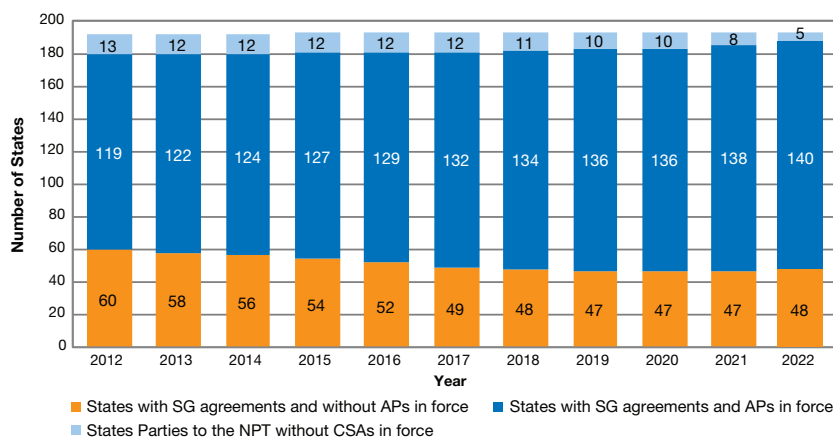
The status of safeguards agreements and APs as of 31 December 2022 is shown in Table A6 in the Annex to this report. During 2022, a CSA with a small quantities protocol (SQP) and an AP entered into force for Cabo Verde and Guinea-Bissau. A CSA with an SQP entered into force for the

<sup>7</sup> Albania, Andorra, Armenia, Australia, Austria, Bangladesh, Belgium, Botswana, Bulgaria, Burkina Faso, Canada, Chile, Croatia, Cuba, the Czech Republic, Denmark, Ecuador, Estonia, Finland, Germany, Ghana, Greece, Holy See, Hungary, Iceland, Indonesia, Ireland, Italy, Jamaica, Japan, Jordan, Kazakhstan, the Republic of Korea, Kuwait, Latvia, Libya, Liechtenstein, Lithuania, Luxembourg, Madagascar, Mali, Malta, Mauritius, Monaco, Montenegro, the Netherlands, New Zealand, North Macedonia, Norway, Palau, Peru, the Philippines, Poland, Portugal, Romania, Seychelles, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Tajikistan, Türkiye, the United Republic of Tanzania, Uruguay, Uzbekistan and Viet Nam.

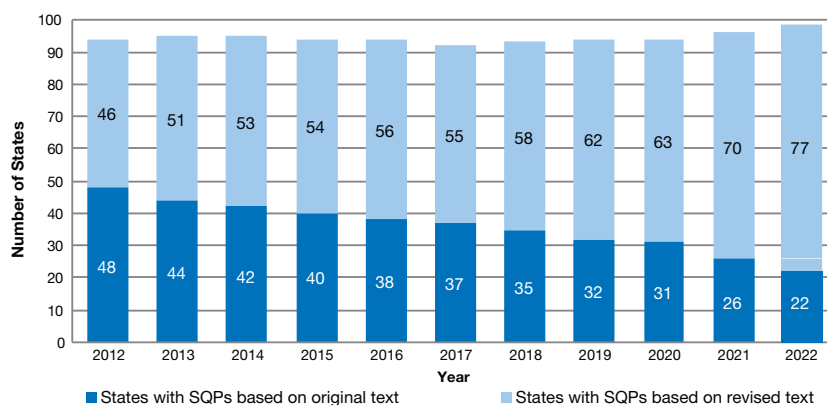
<sup>8</sup> And Taiwan, China.

State of Palestine<sup>9</sup>. An AP was signed for Sierra Leone. SQPs were amended for the Lao People’s Democratic Republic, Namibia, Suriname and Tuvalu. An SQP was rescinded for Lithuania.

The Agency continued to facilitate the conclusion of safeguards agreements and APs, and the amendment or rescission of SQPs. At the end of 2022, 99 States with CSAs in force had operative SQPs, of which 77 SQPs were based on the revised standard text. Eleven States had rescinded their SQPs. The Agency continued to implement the *Plan of Action to Promote the Conclusion of Safeguards Agreements and Additional Protocols*, which was updated in September 2022.



Number of APs for States with safeguards agreements in force, 2012–2022 (the Democratic People’s Republic of Korea is not included).



Number of States with SQPs, 2012–2022.

### Islamic Republic of Iran

Between 16 January 2016 and 23 February 2021, the Agency, in light of UN Security Council resolution 2231 (2015), verified and monitored the Islamic Republic of Iran’s (Iran’s) implementation of its nuclear-related commitments under the Joint Comprehensive Plan of Action (JCPOA). From 8 May 2019 onwards, however, Iran reduced the implementation of those commitments on a step-by-step basis and, from 23 February 2021 onwards, stopped the implementation of those commitments, including the AP. This seriously affected the Agency’s verification and monitoring in relation to the JCPOA, which was exacerbated in June 2022 by Iran’s decision to remove all of the Agency’s equipment previously installed in Iran for surveillance and monitoring activities in relation to the JCPOA. During 2022, the Director General submitted to the Board of Governors, and in parallel to the UN Security Council, 4 quarterly reports and 15 reports providing updates on developments

<sup>9</sup> The designation employed does not imply the expression of any opinion whatsoever concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

between the issuance of the quarterly reports, entitled *Verification and monitoring in the Islamic Republic of Iran in light of United Nations Security Council resolution 2231 (2015)*.

During 2022, despite the Agency's continued efforts to engage Iran in order to resolve outstanding safeguards issues related to the presence of uranium particles of anthropogenic origin at locations in Iran not declared to the Agency, limited progress was made. Unless and until Iran clarifies these issues, the Agency will not be able to provide assurance about the exclusively peaceful nature of Iran's nuclear programme. The Director General submitted four reports to the Board of Governors entitled *NPT Safeguards Agreement with the Islamic Republic of Iran*.

## Syrian Arab Republic

In August 2022, the Director General submitted a report to the Board of Governors entitled *Implementation of the NPT Safeguards Agreement in the Syrian Arab Republic*. The Director General informed the Board of Governors that no new information had come to the knowledge of the Agency that would have an impact on the Agency's assessment that it was very likely that a building destroyed at the Dair Alzour site was a nuclear reactor that should have been declared to the Agency by the Syrian Arab Republic (Syria).<sup>10</sup>

## Democratic People's Republic of Korea

In September 2022, the Director General submitted a report to the Board of Governors and the General Conference entitled *Application of Safeguards in the Democratic People's Republic of Korea*. In 2022, no verification activities were implemented in the field, but the Agency continued to monitor developments in the nuclear programme of the Democratic People's Republic of Korea (DPRK) and to evaluate all safeguards relevant information available to it. The Agency did not have access to the Yongbyon site or to other locations in the DPRK. Without such access, the Agency cannot confirm the operational status or configuration/design features of the facilities or locations, or the nature and purpose of the activities conducted therein. The continuation of the DPRK's nuclear programme, a clear violation of relevant UN Security Council resolutions, is deeply regrettable.

## Enhancing Safeguards

### *State-level safeguards implementation*

The Agency continued to enhance the consistency and effectiveness of safeguards implementation through a project aimed at improving the development and implementation of State-level approaches (SLAs) using a structured approach. Performance targets were embedded in a new dedicated IT application in 2022 to support acquisition path analysis and the development of SLAs. This application simplified the process and facilitated the updating of SLAs for 16 States with the broader conclusion during the year. These SLAs will be implemented in 2023.

### *Cooperation with State and regional authorities*

In 2022, the Agency conducted over 50 training events for personnel responsible for overseeing and implementing State systems of accounting for and control of nuclear material (SSACs) and regional systems of accounting for and control of nuclear material. These events were a combination

<sup>10</sup> The Board of Governors, in its resolution GOV/2011/41 of June 2011 (adopted by a vote), had, inter alia, called on Syria to urgently remedy its non-compliance with its NPT Safeguards Agreement and, in particular, to provide the Agency with updated reporting under its Safeguards Agreement and access to all information, sites, material and persons necessary for the Agency to verify such reporting and resolve all outstanding questions so that the Agency could provide the necessary assurance as to the exclusively peaceful nature of Syria's nuclear programme.



*A colleague learns about remaining webinars in the 2022 interactive webinar series.*

of in-person and virtual training courses, as well as scientific visits. In total, more than 450 experts from 70 States were trained on safeguards-related topics. This work was carried out with the support of Australia, Japan, the Republic of Korea, the United States of America and the European Commission, and took place in conjunction with the Asia–Pacific Safeguards Network. The Agency updated the safeguards e-learning website on the Cyber Learning Platform for Network Education and Training ([elearning.iaea.org](http://elearning.iaea.org)), which was visited by more than 700 new users over the course of the year. In total, representatives from 100 States were registered on the safeguards e-learning site by 31 December 2022.

The Agency launched a series of interactive webinars aimed at enhancing national authorities' understanding of their Agency safeguards obligations, and supporting effective and efficient safeguards implementation. Five webinars were held, covering topics such as strengthening SSACs, AP reporting and ISSAS missions. With an average of 190 participants for each session, a total of over 1500 individuals representing over 100 States participated.

To further help States strengthen the effectiveness of their State or regional authority responsible for safeguards implementation (SRA) and of their respective SSACs, the Agency continued to implement the IAEA Comprehensive Capacity-Building Initiative for SSACs and SRAs (COMPASS) in the seven participating States. Areas of assistance under the initiative included training, stakeholder outreach, legislation and regulation, information management and technology, equipment, and normative documentation. During 2022, 11 Member States contributed in-kind support to the implementation of 18 COMPASS activities, including scientific visits, expert visits, SSAC webinars, and the development of safeguards procedures and national training plans.

### **Safeguards equipment and tools**

Notwithstanding residual travel restrictions due to the COVID-19 pandemic, the Agency ensured that instrumentation and monitoring equipment used by inspectors during in-field verification activities or installed in nuclear facilities continued to operate satisfactorily. By the end of the year, 1782 unattended safeguards data streams were being collected remotely from 159 facilities in 32 States<sup>11</sup> around the world. The Agency also had 1414 cameras operating or ready to use at 238 facilities in 35 States<sup>12</sup> and the transition to the latest generation of surveillance systems (based on DCM-C5/-A1 camera modules) was more than 90% complete.

<sup>11</sup> And Taiwan, China.

<sup>12</sup> And Taiwan, China.





*A member of the NDA Instruments team explains the robotized Cherenkov viewing device.*

In 2022, Member State Support Programmes (MSSPs) remained essential to enabling the testing and validation of new safeguards technologies to address new verification challenges. The next generation Cherenkov viewing device was used routinely at facilities with large inventories of low burnup and/or long-cooling-time spent fuel assemblies. The robotized Cherenkov viewing device was successfully tested thanks to MSSP support and was used for safeguards verification in one Member State.

The Agency started to replace traditional E-CAP metal seals with field verifiable passive seals, providing inspectors with the possibility of verifying the seals' integrity on site, reducing the effort related to the repatriation of passive seals to Agency Headquarters for verification. In 2022, the active universal asymmetric seal was authorized and will start, in 2023, to replace the electronic optical sealing system, providing the Agency with an optimized life cycle cost. The laser curtain for containment, which uses lasers to detect possible intrusion in a safeguarded area in a nuclear facility, was used for the first time in 2022.

A new high resolution cadmium zinc telluride detector was validated by Agency technical experts. Its integration into various non-destructive assay systems will support the standardization of parts and reduce the need for specific training for inspectors.

### ***Safeguards analytical services and methodologies***

As of December 2022, the Agency's Network of Analytical Laboratories (NWAL) consisted of the Agency's Safeguards Analytical Laboratories and 25 other qualified laboratories in various Member States. During the year, six additional laboratories for sample analysis and reference material provision were in the process of qualification.

In 2022, the Agency collected 604 nuclear material samples for nuclear material accountancy and 117 uranium samples for material characterization. The large majority of these were analysed by the Agency's Nuclear Material Laboratory. In addition, five heavy water samples were collected for analysis by the NWAL. The Agency also collected 516 environmental samples.

## Developing the Safeguards Workforce

In 2022, the Agency conducted 45 distinct safeguards staff training courses (as some were held more than once, a total of 92 offerings were provided overall, of which 26 were held outside Vienna), helping to provide safeguards inspectors, analysts and support staff with the necessary core and functional competencies. The Introductory Course on Agency Safeguards for Agency inspectors was held for 12 new inspectors. The Department of Safeguards also conducted a webinar series on seven key topics in safeguards implementation, building capacity and establishing a culture of continuous learning for all staff in the Department.

The Safeguards Traineeship Programme for young graduates and junior professionals commenced in February 2022, involving nine participants (including five women) from Algeria, Cameroon, Costa Rica, Guyana, Nigeria, Panama, Tajikistan, the United Republic of Tanzania and Yemen.

## Partnerships

The Agency forged new partnerships in support of Agency safeguards during the course of the year. To further broaden the support base for Agency safeguards, the Agency also signed Practical Arrangements with the Open Nuclear Network and the Henry L. Stimson Center. The Agency published *Enhancing Capabilities for Nuclear Verification: Resource Mobilization Priorities* in 2022 to support its resource mobilization for safeguards by identifying a prioritized set of capabilities for which the Department is seeking partner support.

## Safeguards Symposium

In 2022, the Agency organized its 14th Symposium on International Safeguards with the theme 'Reflecting on the Past and Anticipating the Future'. The Symposium reflected on the experience gained and lessons learned over the course of decades of safeguards implementation; anticipated new challenges and opportunities; and identified the actions, stakeholders and partnerships necessary to prepare for continued Agency success in the decades ahead. Some 700 registered participants, of whom 36% were women, from 124 States and 15 organizations attended the event. The Symposium's programme, video recordings, papers, e-posters and more are available on the Symposium website. The updated *IAEA Safeguards Glossary* was launched during the Symposium.



*The Director General meets the 2022 Safeguards Traineeship Programme participants.*

## A New Field Verifiable Passive Seal for Safeguards

Seals are a key part of every Agency inspector's verification toolkit. Annually, nearly 30 000 seals — attached to nuclear material, facility-critical equipment or the Agency's own safeguards equipment — are verified in nuclear facilities around the world. Seals are one way to maintain continuity of knowledge for nuclear material. Verifying that a seal has not been tampered with proves that no nuclear material has been moved from a sealed container. Similarly, seals guarantee the integrity of the Agency's on-site safeguards equipment, such as video cameras.

In 2022, the Agency began to replace the traditional passive seal deployed since the 1960s with a new field verifiable passive seal (FVPS). In developing the new seal, Agency experts considered advancements in materials, modern technologies and machining techniques in order to satisfy the highly specialized requirements of an effective seal. The iterative process, from concept to fully functional, secure and authorized seal, took 12 months of dedicated work by Agency staff, including designing, prototyping, destructive testing and assessment of thousands of seal variations. Significant work was also undertaken in 2022 to ensure that the FVPS sealing system was fully integrated within the Agency's safeguards systems and that all required resources were in place to support the launch of this new capability. Considerable financial and technological support provided by a Member State was instrumental in the successful development of the FVPS.

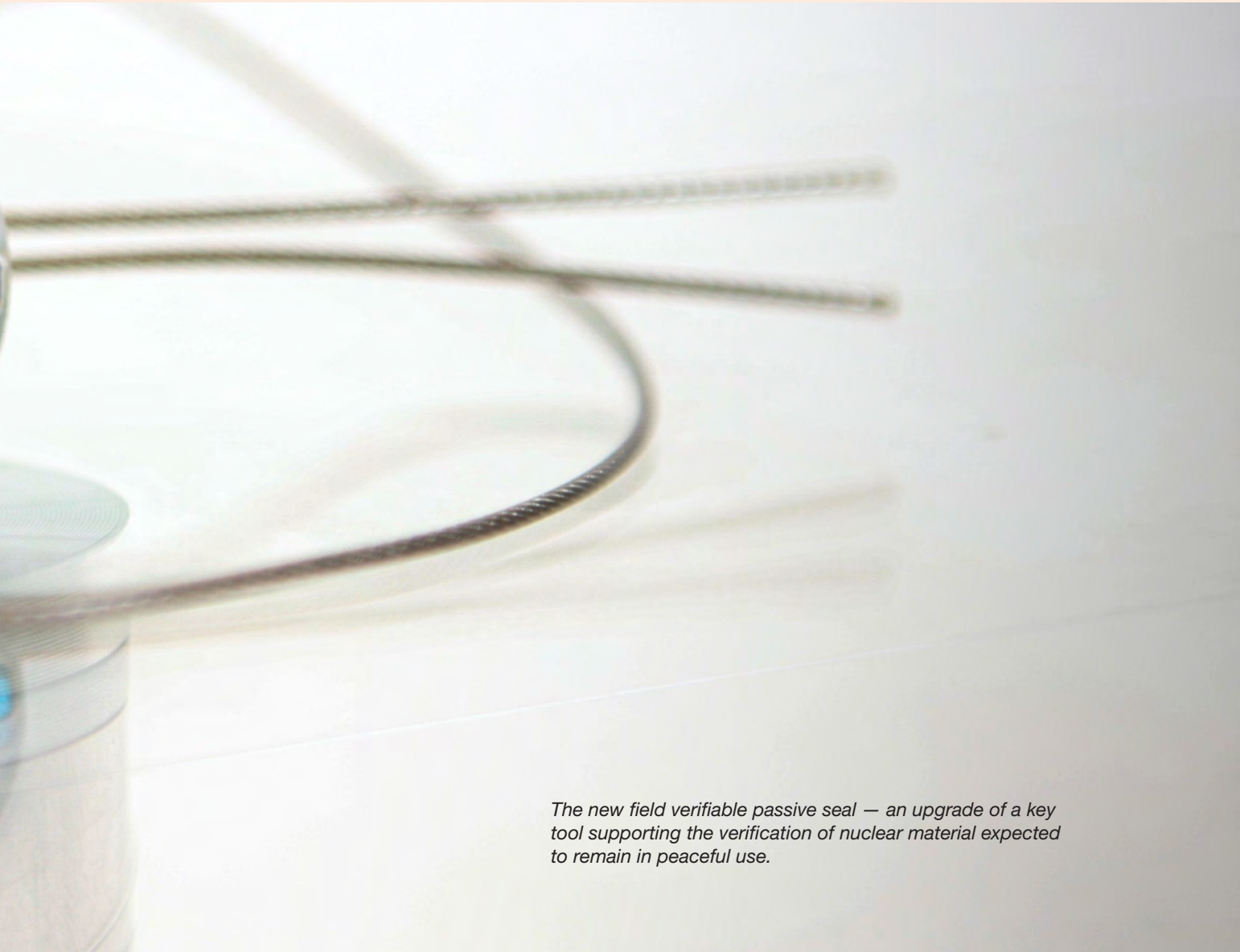


The result is a state-of-the-art seal made from aluminium and polycarbonate, unlike the traditional seal, which was made from copper and brass. The new seal requires no tools to apply, no maintenance while deployed and no batteries. Its components have unique features and pattern designs etched into their surfaces that cannot be replicated without detection. This makes the new seal even more secure and enables the verification and reporting carried out by inspectors to be streamlined.

With the traditional seal, the wire needed to be cut and the seal brought back to Headquarters for verification. In contrast, the device used to verify the new seal contains dedicated software that enables verification to take place in the field by checking reference images and data, which informs the inspector about where, when and by whom the seal was originally attached and verified.

“The FVPS is a significant upgrade to an important tool for IAEA inspectors,” said Massimo Aparo, Deputy Director General and Head of the Department of Safeguards. “This state-of-the-art seal will strengthen the effectiveness and efficiency of Agency safeguards.”

In 2022, the Agency produced and deployed several of the new seals. The Agency plans to expand their use in 2023, with the FVPS eventually replacing all of the traditional seals, especially those currently applied in areas that are hard to access.

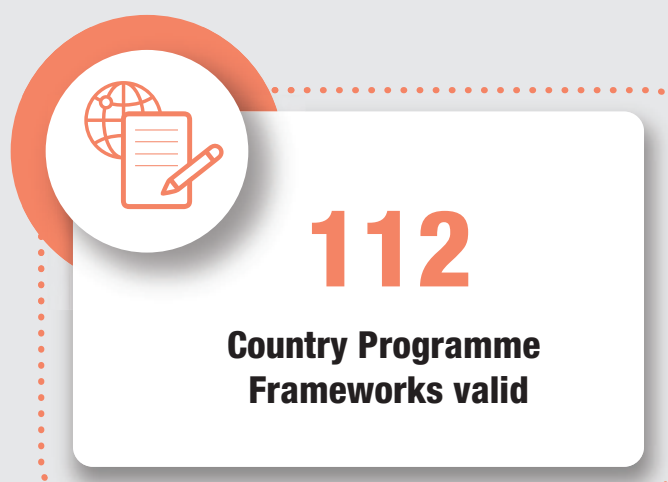
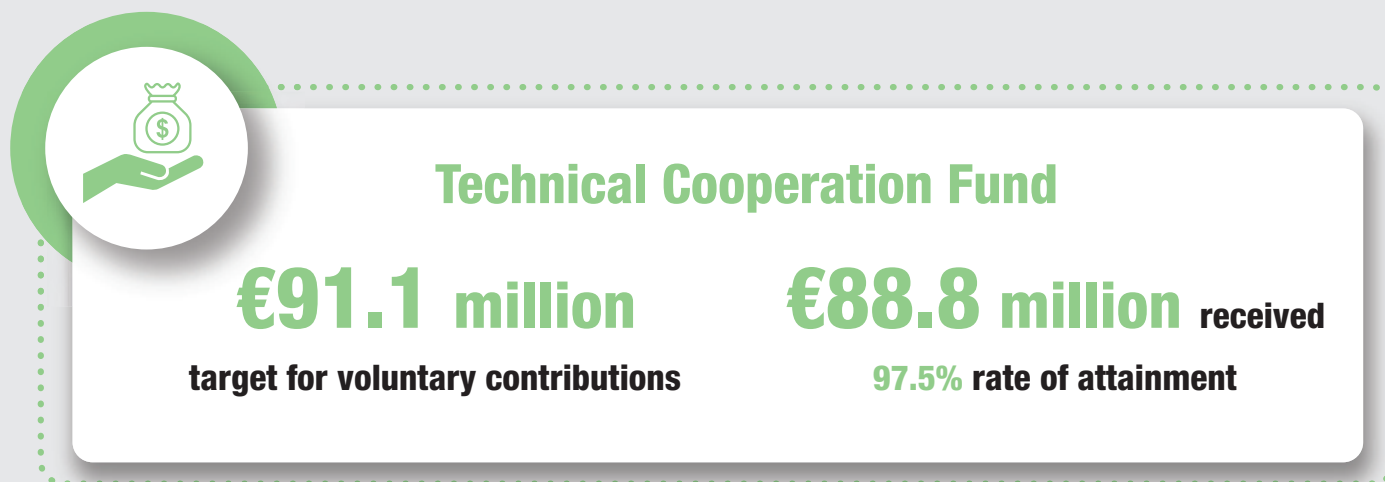


*The new field verifiable passive seal — an upgrade of a key tool supporting the verification of nuclear material expected to remain in peaceful use.*

The background is a deep blue gradient with several flowing, multi-line patterns in lighter shades of blue and white, creating a sense of motion and depth. The lines are curved and overlap, giving the impression of a dynamic, interconnected network or data flow.

# **Technical Cooperation**

# Management of Technical Cooperation for Development



# 2022



**159**

**regional and interregional  
training courses**

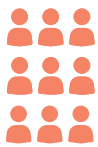


**135**

**projects closed in 2022**

**530**

**projects in closure at the end of 2022**



**1436**

**fellows and  
scientific visitors**

**3072**

**training course  
participants**



**1881**

**purchase  
orders issued**



**value of purchase orders issued**

**€66.5 million**

# Management of Technical Cooperation for Development

## Objective

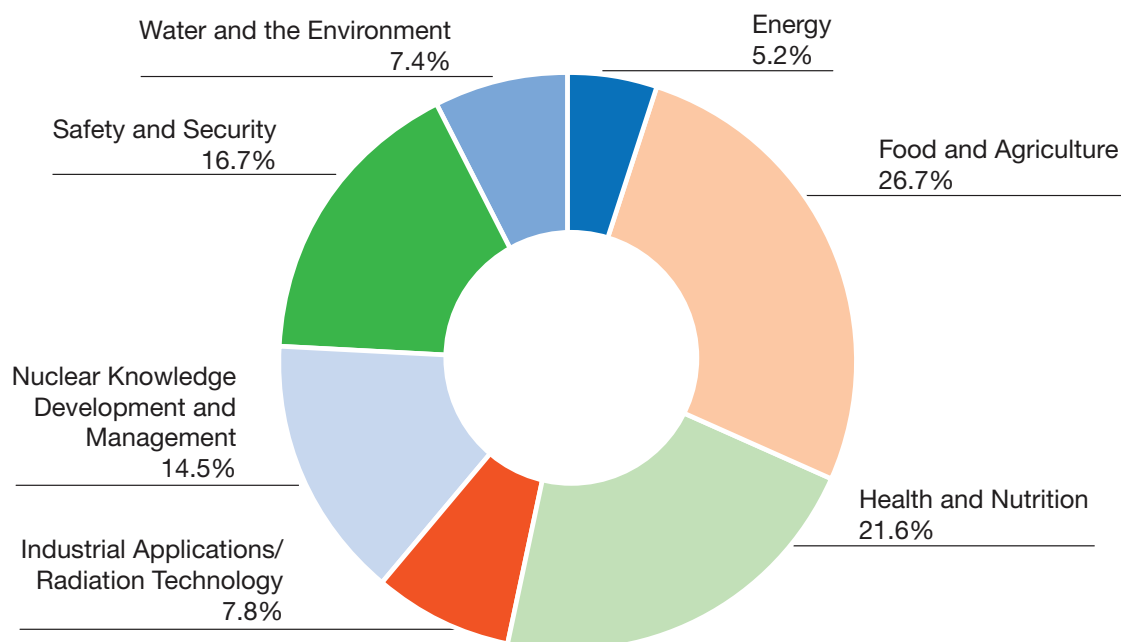
To manage, develop and implement a needs-based, responsive technical cooperation programme in an effective and efficient manner, and thus to strengthen the technical capacities of Member States in the peaceful application and safe use of nuclear technologies for sustainable development.

## The Technical Cooperation Programme

### Programme delivery

The technical cooperation (TC) programme is the Agency's major vehicle for transferring nuclear technology and building capacity in nuclear applications in Member States. It supports national efforts to achieve development priorities, including the targets underpinning the Sustainable Development Goals (SDGs), and encourages cooperation between Member States and with partners.

The main areas of Agency technical cooperation in 2022 were food and agriculture, health and nutrition, and safety and security.

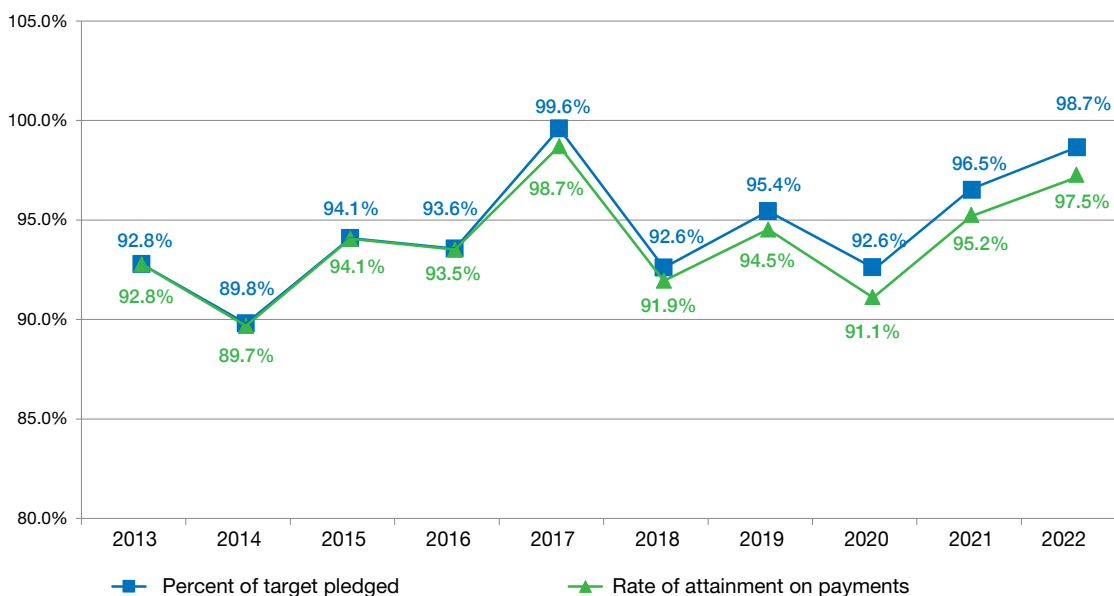


Technical cooperation programme disbursements (actuals) by technical field for 2022. (Percentages do not add up to 100% owing to rounding.)



## Financial highlights

Payments to the 2022 Technical Cooperation Fund (TCF) totalled €93.7 million (including assessed programme cost arrears, national participation costs and miscellaneous income). The rate of attainment on payments at the end of 2022 reached 97.5%. The TCF implementation rate was 84.4%.



*Trends in the rate of attainment, 2013–2022.*

## Country Programme Frameworks and Revised Supplementary Agreements

Nineteen Country Programme Frameworks (CPFs) were signed in 2022, with the total number reaching 112 by the end of the year.

### 19 CPFs were signed in 2022

|                    |           |                  |             |
|--------------------|-----------|------------------|-------------|
| Belarus            | Estonia   | Mongolia         | Qatar       |
| Botswana           | Fiji      | Montenegro       | Rwanda      |
| Côte d'Ivoire      | Guatemala | Nepal            | Saint Lucia |
| Dominican Republic | Jordan    | Papua New Guinea | Viet Nam    |
|                    | Malaysia  | Philippines      | Zimbabwe    |

The number of Revised Supplementary Agreements Concerning the Provision of Technical Assistance by the International Atomic Energy Agency stood at 143 at the end of 2022.

## Rays of Hope

In February, on the margins of the African Union Summit, Director General Rafael Mariano Grossi and President Macky Sall of Senegal launched the Rays of Hope initiative, which aims to support Member State efforts to increase access to radiation medicine services. The IAEA Director General also issued a joint statement with the Director-General of the World Health Organization (WHO), noting that cancer treatment remained inaccessible in many parts of the world and reiterating the commitment of the Agency and WHO to scale up their collaboration with the goal of closing cancer care inequity gaps and accelerating progress towards the achievement of the 2030 Agenda.

Following the launch of Rays of Hope, the Agency established an integrated approach to ensure proper coordination across the Agency. Integrated missions of PACT (imPACT) Review assessments and National Cancer Control Plans (NCCPs) were among the many factors considered when defining priority needs in radiation medicine under Rays of Hope. Resource mobilization efforts continued, with the Agency forging new partnerships with traditional and non-traditional donors to support Member States in addressing gaps in cancer diagnosis and treatment under Rays of Hope.

Support under Rays of Hope has been initiated in seven African countries (Benin, Chad, the Democratic Republic of the Congo, Kenya, Malawi, the Niger and Senegal), and training and equipment needs assessments have been completed for most of these. Benin is building a new hospital that will include radiotherapy services. Chad plans to launch its NCCP in early 2023 and is making preparations for its first cancer therapy centre in N'Djamena. Malawi will complete its bunker in 2023 in preparation for the receipt of a radiotherapy machine and Kenya is planning to expand radiotherapy access. Senegal has recently completed its NCCP, which outlines its goal to scale up cancer care outside Dakar, increasing access in particular in the town of Diamniadio. Nineteen additional countries in the region are completing an assessment of their needs, which include the training of medical professionals and the procurement of diagnostic imaging and radiotherapy equipment.

In Asia and the Pacific, several Member States have also expressed interest in participating in Rays of Hope, including as anchor centres. Resource mobilization in the region is being explored, including extrabudgetary contributions, government cost-sharing and public–private partnerships.

In November, the Board of Governors approved an off-cycle TC project to strengthen radiation therapy and medical imaging in Ukraine. The project aims to strengthen existing services in order to meet increasing demand, in particular at some medical institutions that have become key locations for cancer patients coming from different regions of the country. It will contribute to the effective delivery of cancer diagnosis, management and treatment by providing equipment and strengthening human resource capabilities. The project is being implemented and delivered through existing Agency mechanisms, under the Rays of Hope initiative (with a focus on prioritizing high-impact, cost-effective and sustainable interventions to help meet national needs and commitments) and in partnership, when relevant and necessary, with WHO and other stakeholders.



*The Director General briefs the Group of 77 and China (Vienna Chapter) on topics including Rays of Hope, NUTEC Plastics and ZODIAC during a meeting at the Agency Headquarters in Vienna, 21 April 2022.*

In Latin America and the Caribbean, memoranda of understanding (MOUs) relating to Rays of Hope were signed with Argentina and Cuba in 2022. The former states that the Agency and Argentina will collaborate towards the establishment of an Agency Rays of Hope anchor centre and the latter focuses on coordination, collaboration and control in the Caribbean region.

Uruguay received a state-of-the-art digital mammography unit with tomosynthesis for accurate and detailed breast imaging in 2022. Under Rays of Hope and through the TC project 'Improving Capabilities in Three-Dimensional Mammography (Tomosynthesis)', the Pereira Rossell Hospital received equipment, training and expert advice for acceptance testing. The institution has also established a quality control programme for the improvement of services.

## ZODIAC

Implementation of the Zoonotic Disease Integrated Action (ZODIAC) project is supported through the TC programme under an interregional project entitled 'Supporting National and Regional Capacity in Integrated Action for Control of Zoonotic Diseases', which supports national and regional capacity building in ZODIAC national laboratories (ZNLs). Several virtual interregional training courses and workshops were held in 2022, reaching more than 1000 participants. Topics included generic methods for validating standard operating procedures; the use of the Agency's genetic sequencing services; and current developments relating to whole-genome sequencing platforms. A recorded course on the use of the iVETNet platform was accompanied by two live virtual Q&A sessions in June. The ZODIAC Portal was launched in 2022, providing access to educational and training videos and recordings of ZODIAC briefings.

A virtual interregional workshop on mpox (monkeypox) and Lassa fever infections in animal reservoirs and the risks for public health transmission was held in June and addressed by the IAEA Director General and high-level representatives from the Food and Agriculture Organization of the United Nations (FAO) and WHO. Meeting participants agreed that a system for screening the virus in domestic and wildlife environments was urgently needed, and also discussed how to utilize available diagnostic tools such as reverse transcription–polymerase chain reaction (RT–PCR), one of the most widely used nuclear-derived laboratory methods for detecting various pathogens. Together with the Agency, FAO, WHO and international experts, more than 250 participants from ZNLs agreed to strengthen cooperation and to define research topics to understand the epidemiological role of animal carriers and reservoirs. Using nuclear science and technology, the Agency will work together with ZNLs in Africa, Asia, Europe and Latin America to fine-tune the diagnostic algorithms for the two diseases. These actions will contribute to improved understanding of how these viruses circulate in animals, how they survive in the environment and how they spread from species to species.

A ZODIAC progress meeting for ZODIAC national coordinators and ZNL representatives was conducted for the Africa and Europe regions in January, and for the Asia and the Pacific region in February. Serology and molecular diagnostic equipment was procured for 30 ZNLs (12 from Africa, 5 from Asia and the Pacific, 7 from Europe and Central Asia and 6 from Latin America and the Caribbean) and whole-genome sequencing platforms were procured for 9 ZNLs (3 from Africa, 2 from Asia and the Pacific, 2 from Europe and Central Asia and 2 from Latin America and the Caribbean). In addition, three fellowship training courses on whole-genome sequencing were completed by fellows from Indonesia, Senegal and Tunisia. A first in-person training course on the generic verification of standard operating procedures for serology and molecular diagnostics in ZNLs was implemented in September at the Institut Pasteur de Dakar, Senegal, where 23 participants from 19 French-speaking African Member States received training.

## NUTEC Plastics

The Nuclear Technology for Controlling Plastic Pollution (NUTEC Plastics) initiative focuses on addressing plastic pollution through recycling using radiation technology and through marine monitoring using isotopic tracing techniques. In Africa, actions under a regional project entitled 'Reutilizing and Recycling Polymeric Waste Through Radiation Modification for the Production of Industrial Goods (AFRA)' aim to accelerate the transition to a circular plastic economy using nuclear science and technology. Sixteen African Member States are participating in the project. Interactions with the World Economic Forum's Global Plastic Action Partnership regional working group for Africa have identified areas of synergy under NUTEC Plastics.

Ten countries in Asia and the Pacific are participating in the regional project 'Reutilizing and Recycling Polymeric Waste through Radiation Modification for the Production of Industrial Goods'. Indonesia, Malaysia, the Philippines and Thailand, which, of the ten countries, have the most advanced national plastic recycling programmes, made significant progress in technology development in 2022. Two national stakeholder meetings were held to engage government and potential industrial partners, and the Agency facilitated the participation of the Philippines' research team in the Asian Development Bank Innovation Fair, where the team showcased progress in developing plastic recycling.

In Latin America and the Caribbean, a regional project entitled 'Promoting Radiation Technology in Natural and Synthetic Polymers for the Development of New Products, with Emphasis on Waste Recovery (ARCAL CLXXIX)' aims to demonstrate the feasibility of using radiation technology to convert different types of polymeric waste into value-added products. In November, laboratory staff from Argentina, Chile, Costa Rica, Panama, Peru and the Bolivarian Republic of Venezuela participated in a regional training course in Brazil on scaling up the application of radiation technology from the laboratory scale to the pilot and industrial scale, with an emphasis on waste recovery.

Specialists from the Regional Network of Marine-Coastal Stressors in Latin America and the Caribbean (REMARCO) finalized four harmonized microplastics sampling protocols for coastal areas. This achievement aligns with NUTEC Plastics and will contribute to ensuring harmonized approaches for microplastics monitoring programmes being implemented in the region.

The Agency signed two separate MOUs with Argentina and Cuba, setting out a framework for scientific cooperation under NUTEC Plastics on the control of plastic pollution in Antarctica and the Caribbean. Activities include the organization of expert missions and educational and training activities to build capacity for the collection and analysis of data on the nature and distribution of microplastics.

## Regional Cooperative Agreements and Regional Programming

### Africa

In 2022, 19 new regional TC projects were launched under the umbrella of the African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA). Seventy-six courses delivered training to more than 2200 participants, while almost 90 meetings brought together more than 1550 attendees. Seven new regional AFRA project designs are being prepared for approval for the 2024–2025 TC cycle, with three focusing on integrated approaches to radiation medicine, food and agriculture, and radiation safety.

The 33rd AFRA Technical Working Group Meeting was held in Kigali, Rwanda, in July. The 33rd Meeting of AFRA Representatives took place in hybrid format in Vienna, Austria, during the 66th regular session of the General Conference. At the meeting, delegates endorsed the AFRA Annual Report for 2021 and recognized five new AFRA Regional Designated Centres. At the AFRA High-level Policy Meeting in Cairo, Egypt, in December, delegates adopted a new plan of action and a political declaration setting the strategic direction for AFRA's governance, programme and resource mobilization efforts.

## Asia and the Pacific



The Director General at the launch of RCA programme socioeconomic impact assessment reports.

A ministerial declaration to mark the 50th anniversary of the Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology for Asia and the Pacific (RCA) was issued at a special RCA ministerial-level meeting on the margins of the 66th regular session of the General Conference. The anniversary was also marked by an exhibition and the launch of two new socioeconomic assessment reports conducted by the RCA, with the support of the Agency, on radiotherapy and non-destructive testing projects carried out under the RCA programme. The Agency joined the RCA Regional Office (RCARO) to celebrate the 20th anniversary of the office's establishment at an international symposium sponsored by the Ministry of Science and ICT and other relevant institutes in the Republic of Korea and entitled 'Cooperative Leadership in Nuclear Science and Technology and Sustainable Development in the Asia-Pacific Region: Future Vision of the RCARO'.

The States Parties to the Co-operative Agreement for Arab States in Asia for Research, Development and Training related to Nuclear Science and Technology (ARASIA) marked the 20th anniversary of the agreement at a ceremony on the margins of the 66th regular session of the General Conference. The publication *Breaking Through to Progress: A Collection of Success Stories from ARASIA in Collaboration with IAEA Technical Cooperation in Asia and the Pacific* was launched by Director General Grossi in the presence of ambassadors and representatives from ten ARASIA States Parties and the ARASIA Chair. ARASIA also published a booklet which provides detailed information on the region's secondary standards dosimetry laboratories (SSDLs), and on the services offered by ARASIA Regional Resource Centres.



Students participating in the 2021 Nuclear Science and Technology Education Competition visit the International Centre for Synchrotron Light for Experimental Science and Applications in the Middle East, in Jordan. (Photograph courtesy of I. Lim/Philippines)

## Europe

Thirty-three Member States in the Europe region endorsed the *Regional Profile for Europe and Central Asia for 2022–2027* at a meeting of National Liaison Officers (NLOs) on the margins of the 66th regular session of the General Conference. The document sets out regional priorities in four thematic areas — nuclear and radiation safety, nuclear energy, human health, and isotope and radiation technologies — and will act as a reference for Member States and the Secretariat in the formulation of regional TC projects.

The *Strategic Framework for the Technical Cooperation Programme in the Europe Region 2019–2025* guides the implementation of TC activities in close collaboration with Member States and is aligned with the priorities identified in the Regional Profile and CPFs. Considerable effort was focused on capacity building in 2022, with 500 human resource activities implemented during the year. Four hundred and twenty-one equipment procurement requisitions were processed.

At the biennial meeting of NLOs from the Europe region, held in Istanbul, Türkiye, in May, regional proposals for the 2024–2025 TC cycle were prioritized, and 79 national and 13 regional TC projects were moved to the design phase.

A publication entitled *Energy Planning Support to Europe and Central Asia: Case Studies* was issued by project counterparts, highlighting actions implemented by six countries in Europe and Central Asia to achieve low-carbon energy targets in line with the Paris Agreement on climate change. In October, 14 countries met in Cyprus to exchange good practices in the development of integrated energy and climate plans.



*Collection of Aedes mosquito larvae in the public drainage system, Cyprus.*

### **Latin America and the Caribbean**

The 23rd Meeting of the Regional Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL) Technical Coordination Board (OCTA) took place in Vienna, Austria, in May and was attended by 16 national ARCAL representatives and representatives from Spain. Meeting participants reviewed the implementation of ARCAL's outreach and communication strategy to promote nuclear applications, as well as partnership strategies. Needs for project monitoring and evaluation planning were discussed, and ARCAL project proposals were selected for submission for the 2024–2025 TC cycle. Guidelines for the implementation of the Regional Strategic Profile 'Agenda ARCAL 2030' were finalized, defining baselines, indicators and goals to be achieved during the period 2022–2029.



*Senior representatives of CARICOM technical institutions meet the Director General to discuss ongoing collaboration facilitated through the TC programme.*

Eighteen NLOs, National Liaison Assistants and senior representatives of Caribbean Community (CARICOM) technical institutions and Agency Member States from CARICOM attended the first in-person meeting of the Regional Steering Committee of the Regional Strategic Framework (RSF) for Technical Cooperation with IAEA-CARICOM Member States: 2020–2026 in Vienna, Austria, in November. The meeting was held to assess progress achieved under the RSF and to propose actions to improve its implementation, including aligning regional projects proposed for the 2024–2025 TC cycle in order to achieve RSF outputs.

## Programme of Action for Cancer Therapy (PACT)

Four imPACT Reviews to assess cancer control capacities and needs were conducted in 2022 in Colombia, the Lao People's Democratic Republic, the Syrian Arab Republic and Uzbekistan. A series of national cancer control programme (NCCP) webinars was organized jointly with WHO and the International Agency for Research on Cancer (IARC), providing a forum for dialogue with Member States to share lessons learned on NCCP development and implementation.

The Agency participated in several high-level events, including World Health Assembly and WHO Regional Committee meetings, and supported the participation of ten Member State counterparts in the World Cancer Congress to enable experience sharing. The Agency also led the IAEA-IARC-WHO annual consultation in Geneva and collaborated with the Union for International Cancer Control (UICC) and City Cancer Challenge to strengthen partnership.

An article entitled 'Evolution of the joint IAEA, IARC and WHO cancer control assessments (imPACT Reviews)' was published in *The Lancet Oncology* to coincide with the publication of the *Methodology for Integrated Missions of the Programme of Action for Cancer Therapy (imPACT Reviews)* (IAEA Services Series No. 46).

In cooperation with the International Cancer Control Partnership (ICCP), countries receiving imPACT Reviews and support for the development of national cancer control programmes and that could benefit from ICCP advisory support in implementing cancer plans were identified.



An imPACT Review to assess cancer control capacities and needs was conducted in Colombia in 2022. (Photograph courtesy of Colombia's Instituto Nacional de Cancerología)



## Strengthening the Quality of the Technical Cooperation Programme

The TC Project Report Processing System (TC-Reports) was updated to facilitate progress tracking and link yearly progress with final achievements.

The Agency strengthened its results based approach to ensure sustainable and cost-effective benefits. Performance indicators were refined to measure programme performance and results based monitoring was strengthened.

## Outreach and Communication

New outreach material on the TC programme issued in 2022 included *The IAEA Technical Cooperation Programme: Selected Highlights 2021*, a special report for COP27 entitled *Nuclear Technologies and Climate Adaptation in Africa* and a video on cancer prepared in partnership with the British Broadcasting Corporation. To reduce printing costs and paper usage, materials were increasingly shared electronically, including through QR indexes at events. Social media continued to offer a cost-effective channel for outreach on the programme, and both the @IAEATC and @iaeapact Twitter accounts grew significantly.

### Technical Cooperation outreach in 2022

|             |                                                                                    |
|-------------|------------------------------------------------------------------------------------|
| <b>124</b>  | Agency web articles on technical cooperation                                       |
| <b>7907</b> | @IAEATC Twitter followers (growth of 12% from 2021) and <b>453</b> tweets posted   |
| <b>2502</b> | @iaeapact Twitter followers (growth of 23% from 2021) and <b>185</b> tweets posted |
| <b>4594</b> | LinkedIn followers and <b>72</b> posts                                             |

Six TC side events were organized during the 66th regular session of the General Conference. They were entitled 'Revealing Secrets Using Nuclear Techniques', 'Diagnostic Radiology Medical Physicists: Who Are We?', '20th Anniversary of ARASIA', 'Plans for PCMF Upgrade', 'Enhancing Capacities of Member States in Africa to Achieve Food Security Through the Peaceful Use of Nuclear Techniques', and 'Improving National Frameworks for Radiation Protection in Medical Exposure in Europe and Central Asia'. Two exhibitions on technical cooperation were organized, at the General Conference and at the Global South–South Development Expo.

## Cooperation with the United Nations System

Throughout 2022 the Agency continued to strengthen its collaboration with the UN system at every level, with a view to building stronger synergies and ensuring that nuclear and nuclear-derived science, technology and innovation were considered part of the solution to global crises including food insecurity, climate change and energy scarcity.

Agency assistance to Member States in support of the 2030 Agenda for Sustainable Development and the attainment of the SDGs was highlighted at high-level events including the fifth session of the United Nations Environment Assembly, the UN High-level Political Forum on Sustainable Development, the UN Multi-stakeholder Forum on Science, Technology and Innovation for the Sustainable Development Goals, the G-20 Research and Innovation Initiative Gathering and the associated ministerial meeting. The Agency also participated in the UN Global South–South Development Expo and in meetings of the Interdepartmental Task Force on African Affairs organized



*Deputy Director General Hua Liu addresses delegates at the Seminar on Technical Cooperation for Permanent Missions held in Geneva in 2022.*

by the UN Office of the Special Adviser on Africa. Participation in such events facilitated the Agency's engagements with international financial institutions, the private sector and philanthropic foundations — all essential to resource mobilization, and in particular to actions focused on the Agency's flagship initiatives NUTEC Plastics, Rays of Hope and ZODIAC.

The Agency signed a cooperation agreement with the World Meteorological Organization in January to jointly support the implementation of an interregional project to build capacity in using stable isotopic techniques to attribute the source of greenhouse gases in the atmosphere.

The Agency, IARC and WHO met following the 2022 World Cancer Congress for the annual strategic consultation on cancer control to facilitate planning for efficient and effective collaboration between the three agencies.

As part of its cooperation with organizations in the UN system, the Agency signed an agreement with the Abdus Salam International Centre for Theoretical Physics and the University of Trieste to support a master's programme geared towards human capacity building in the area of medical physics.

## **Partnership Agreements, Practical Arrangements and Memoranda of Understanding**

Significant engagement with donors, including Member States, financial institutions and the private sector, continued throughout 2022 in support of Rays of Hope and the other major initiatives. The Agency signed two MOUs with Argentina, one of which focuses on cooperation in the implementation of Rays of Hope through, inter alia, collaboration towards the establishment of an IAEA Rays of Hope anchor centre. The second MOU sets out a framework for scientific cooperation to support the control of plastic pollution in Antarctica under NUTEC Plastics. A further two MOUs were signed with Cuba, also covering Rays of Hope and cooperation to support the control of plastic pollution in the Caribbean under NUTEC Plastics.

In June, the Agency signed an MOU with Morocco, establishing a framework for cooperation in fighting cancer and zoonotic diseases. Subsequently, in December, the Agency signed Practical Arrangements with Mohammed VI Polytechnic University in Morocco to promote collaboration in education, training, research and development on the peaceful uses of nuclear technology.

In September, Foreign Minister of Argentina Santiago Cafiero and Director General Grossi signed an action plan with the Community of Latin American and Caribbean States to establish collaboration in the peaceful application of nuclear science and technology. The action plan also

aims to strengthen regional infrastructure and support the development of national capacities that will contribute to the achievement of the SDGs.

In December, the Agency signed Practical Arrangements with three Chinese institutions — the Beijing Research Institute of Uranium Geology, the East China University of Technology and the Beijing Research Institute of Chemical Engineering and Metallurgy — to advance cooperation in the exploration and exploitation of uranium resources.

In January 2022, a new interregional project was initiated to improve Member State knowledge and build capacity for the eventual deployment of small modular reactors. The project has attracted the interest of donors and resources have been mobilized from five countries.

### **Activities and actions under existing agreements**

Cooperation between the Agency and the Asian Development Bank (ADB) was expanded under the Cooperation Framework Agreement to cover Rays of Hope, NUTEC Plastics, ZODIAC and agriculture. The Agency participated in the Second ADB Innovation Fair, where it demonstrated how nuclear technology could be applied to manage plastic waste through the NUTEC Plastics initiative.

In February, Practical Arrangements between the Agency and the African Union for cooperation in the safe, secure and peaceful use of nuclear technologies for sustainable development in Africa were renewed. In September, Practical Arrangements between the Agency and the African Commission on Nuclear Energy were renewed to support Agency Member States in Africa in the peaceful use of nuclear science and technology for development, and nuclear safety, security and safeguards.

Cooperation was expanded under existing Practical Arrangements with Cambodia and Viet Nam, and the Lao People's Democratic Republic and Viet Nam, in the areas of non-destructive testing, nuclear medicine and mutation breeding, and the Practical Arrangements were extended for a further five years. Four capacity-building activities were conducted with the support of Viet Nam.

Programmatic partnerships were advanced within the framework of existing Practical Arrangements with City Cancer Challenge and the UICC, including through consultations on engaging civil society stakeholders in order to promote participatory imPACT Reviews and national cancer control planning work in countries including Colombia and Kenya.

In collaboration with the Pan American Health Organization and WHO, the Agency implemented the Optimization of Protection in Paediatric Interventional Radiology in Latin America and the Caribbean (OPRIPALC) programme with the goal of promoting a safety culture in paediatric radiology and strategies for its optimization, including the determination and use of appropriate reference levels.

### **Legislative Assistance**

The Agency continued to provide legislative assistance to Member States through workshops, missions and meetings to raise awareness, advise and train on developing and revising national legislation and adhering to and implementing relevant international legal instruments.

Seven Member States (Burkina Faso, Central African Republic, Jordan, Kuwait, Libya, Nigeria and Somalia) received country-specific bilateral legislative assistance through written comments and advice on drafting national nuclear legislation.

Eighteen legislative assistance activities were conducted, including ten meetings with decision makers, policymakers and senior officials (Benin, Burkina Faso, Comoros, Croatia, Egypt, El Salvador, Kenya, Kuwait, Saudi Arabia and Senegal) to raise awareness about the various elements of comprehensive national nuclear legislation and/or the importance of adhering to relevant international legal instruments and to discuss specific issues, and eight national workshops on nuclear law (Benin, Egypt, Kenya, Kuwait, Nigeria, Saudi Arabia and Senegal) to increase stakeholders' understanding of international legal instruments and the various elements of comprehensive national nuclear legislation and to address specific topics of interest for each Member State.

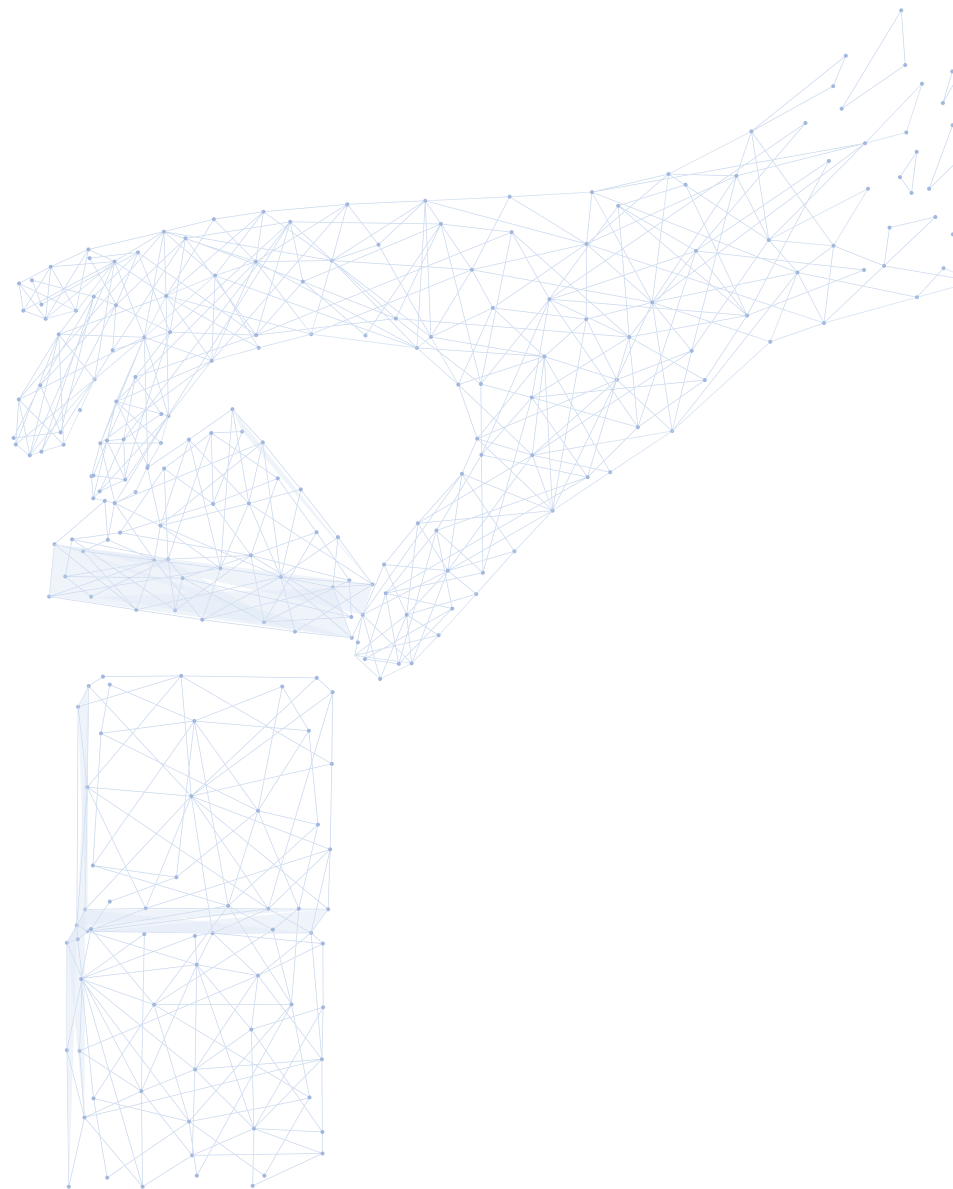
Three regional and subregional workshops were held for Member States in Asia and the Pacific (Viet Nam, August 2022), Latin America (Argentina, September 2022) and the Middle East (United Arab Emirates, December 2022).

The Agency organized the tenth session of the Nuclear Law Institute in Vienna, Austria, from 10 to 21 October 2022. This event enabled 57 participants from 54 Member States to acquire a solid understanding of all aspects of nuclear law, with a particular focus on legislative drafting. In addition, the Agency held five webinars on topical issues in nuclear law as part of the nuclear law webinar series launched in 2021.

The Agency held its First International Conference on Nuclear Law: The Global Debate in Vienna in April 2022, bringing together 1124 participants from 127 Member States and 31 organizations.

## Treaty Event

The annual Treaty Event took place during the 66th regular session of the General Conference, providing Member States with an additional opportunity to deposit their instruments of ratification, acceptance, or approval of, or of accession to, the multilateral treaties deposited with the Director General. The event focused on multilateral treaties relating to nuclear safety and security and to civil liability for nuclear damage.

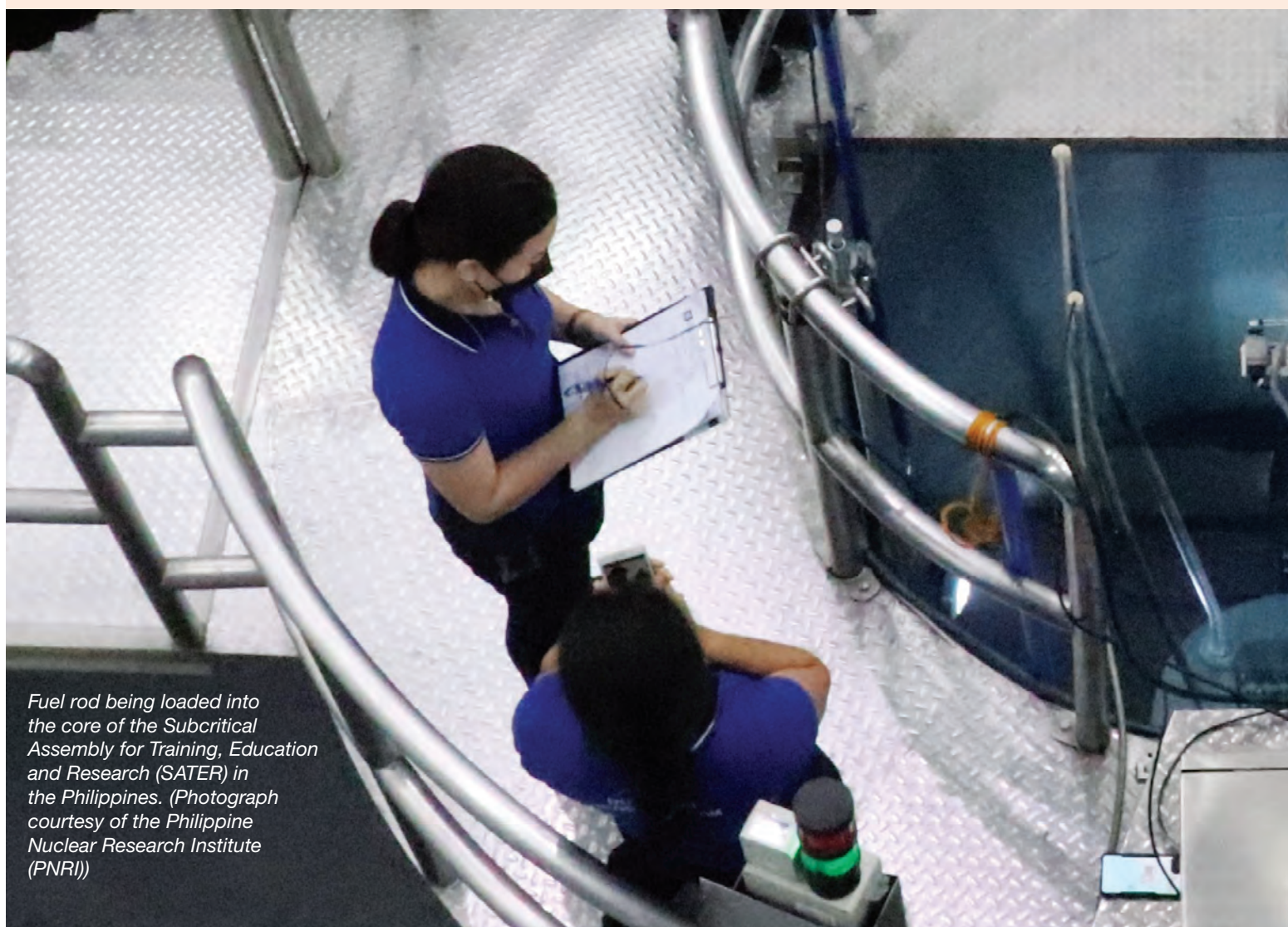


## Nuclear Facility in Philippines Revived After 34 Years

From 1963 to 1988, the Philippines operated a research reactor that offered a wide range of possibilities for research and training in nuclear science as well as isotope production. In 1988, however, the facility was shut down owing to several technical issues and its refurbishment was put on hold.

In recent years, a new research reactor — the Subcritical Assembly for Training, Education and Research (SATER) — was constructed inside the same reactor building. In June 2022, under a technical cooperation project with the Agency, Philippine experts reached a key milestone in bringing SATER into operation as 44 fuel rods from the original research reactor were loaded into SATER's core. With the loading of the 44 fuel rods, the reactor entered the commissioning phase in preparation for routine operation. It is expected that, by 2023, all the commissioning tests will be completed and the reactor will be fully operational, serving as a safe and versatile tool for education and research.

The Philippine Nuclear Research Institute (PNRI), a Government agency responsible for research and development in the nuclear field, has received robust support from the Agency in this endeavour. Under the first related technical cooperation project, launched in 2016, the Agency helped the PNRI: build reactor design capacity by helping personnel attend scientific visits, fellowships and technical workshops; enhance neutron dosimetry by procuring state-of-the-art equipment; and develop national regulations related to research reactors via multiple expert missions.

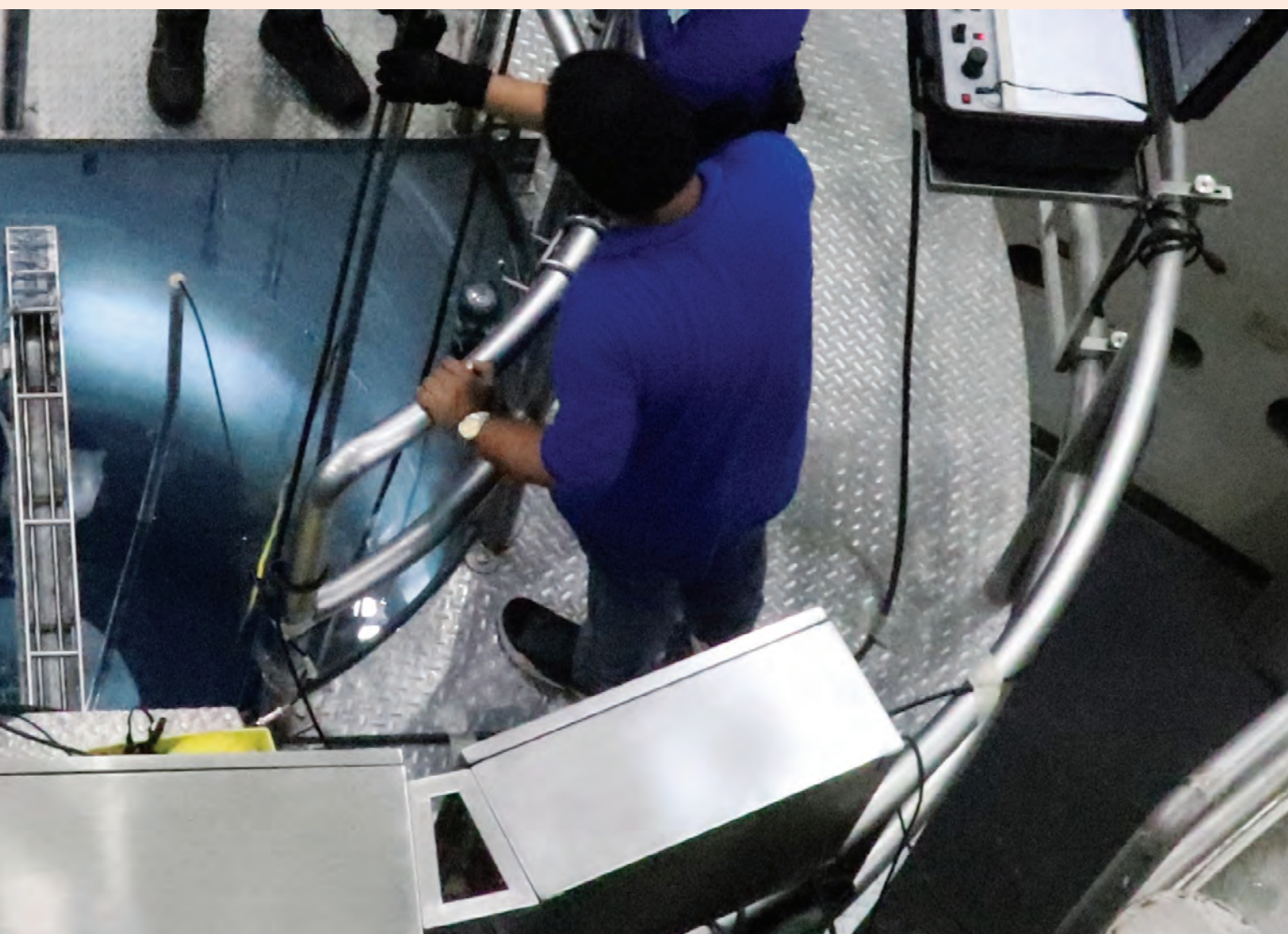


*Fuel rod being loaded into the core of the Subcritical Assembly for Training, Education and Research (SATER) in the Philippines. (Photograph courtesy of the Philippine Nuclear Research Institute (PNRI))*

The second project, which began in 2020 and is ongoing, focuses on reactor engineering, operation and use, as well as the development of a reactor training programme for local specialists. To assist the Philippine regulatory authorities and operating staff with the commissioning of SATER, the Agency has been providing recommendations on licensing and setting up the facility. It has also helped organize various on-site missions by international experts and has assisted the PNRI in strategic planning, which is essential to ensuring SATER's long-term, sustainable use.

"The activation of SATER is a milestone for the Philippines, as the facility will provide significant support in re-establishing nuclear capabilities in the country", said Alvie Asuncion-Astronomo, Associate Scientist in the Department of Science and Technology and former Head of the PNRI's Nuclear Reactor Operations Section.

Subcritical assemblies such as SATER are not only valuable instruments for advancing scientific research but are also used for a variety of practical applications, including in industry, medicine and agriculture. Unlike nuclear power reactors, which are large and are used to generate electricity, research reactors are relatively small and simple, enabling the simulation of various operating conditions. SATER will be used for reactor physics experiments and as a demonstration facility for neutron irradiation and neutron activation analysis. It will be used to train reactor operators, nuclear facility maintenance personnel, radiation protection specialists, regulators, students and researchers.



## Protecting Malta's Cultural Heritage: The Role of Nuclear Technology

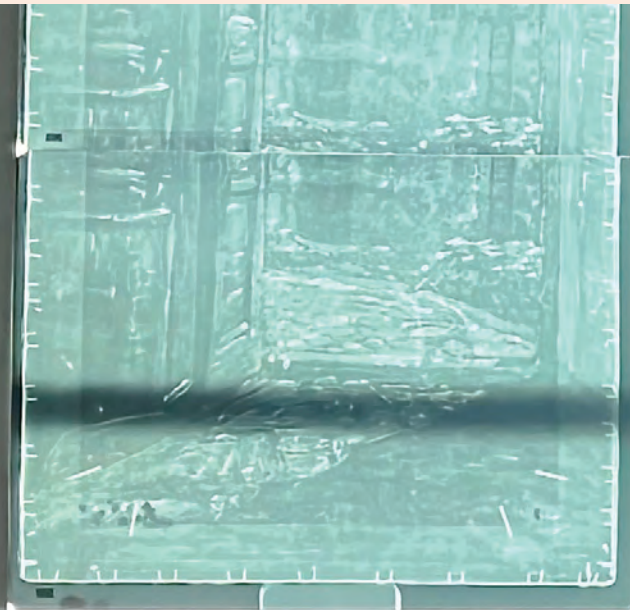
Malta has a rich heritage that includes Neolithic temples, medieval forts and other relics dating back some 8000 years. To protect the country's priceless cultural legacy and preserve it for future generations, Maltese scientists are taking advantage of modern nuclear techniques with the help of the Agency.

Thanks to its long and colourful history, with the first known inhabitants settling on the island as far back as 5900 B.C., Malta boasts a number of UNESCO World Heritage Sites, making it a popular tourist destination. Each year Malta is visited by around 2 million people, who contribute up to 15% of the country's GDP.

"We wouldn't have a thriving tourism industry in Malta if it were not for our extensive and multifaceted cultural heritage", said Joyce Dimech, Permanent Secretary at Malta's Ministry for the National Heritage, the Arts and Local Government. "So we are really engaged and committed to preserving this heritage for posterity", she continued.

At Heritage Malta, the country's cultural preservation agency, experts have been working to characterize materials and artefacts that make up the country's heritage. With the support of the Agency's technical cooperation programme, Maltese experts acquired the necessary equipment and training to use the X-ray diffraction (XRD) nuclear technique, enabling them to study and analyse pottery, pigments, mortars and other millennia-old materials without touching or risking damage to them.

*Heritage Malta is responsible for the conservation and preservation of all artefacts of cultural value in the country. Increasingly, Heritage Malta has turned to radiation technologies, both to analyse artefacts, artworks and ancient relics and to preserve them for future generations.*



The XRD method is a powerful analytical technique that provides researchers with detailed information about the chemical composition of historical objects, as well as their age and, in some cases, their origin. The process is microinvasive, requiring no more than a few specks of the sample. It provides data on the condition of the items, helping experts develop and apply the requisite conservation strategies, and helps identify the original materials comprising the artefacts and the methods used to produce them, offering further insights into how to preserve items before they are lost forever. Such information helps ensure access to artefacts of national and global historic value for future generations.

“We have more than 1 million objects and sites of cultural value in our portfolio, and with the XRD system now delivered, commissioned and already in operation it is helping to solve puzzles and relieve our workload”, said Matthew Grima, Manager of Heritage Malta’s Diagnostic Science Laboratories.

Thanks to the training and XRD equipment provided by the Agency, in 2022 Maltese experts were sufficiently well equipped to share their knowledge and experience beyond the island’s shores, organizing their own training course in Valletta for participants from eight countries in Europe and Central Asia and representing different cultural heritage disciplines.





# Annex

|              |                                                                                                                                                                          |
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|               |                                                                                                                                       |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------|
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**Note:** Tables A38–A43 are available online only at [www.iaea.org/publications/reports](http://www.iaea.org/publications/reports).

**Table A1. Regular Budget allocation and utilization of resources in 2022 by Programme and Major Programme (in euros)**

| Major Programme (MP)/Programme                                               | Original budget    | Adjusted budget    | Expenditure        | Resource utilization | Balance          |
|------------------------------------------------------------------------------|--------------------|--------------------|--------------------|----------------------|------------------|
|                                                                              | US\$/€1            | US\$/€0.949        |                    |                      |                  |
|                                                                              | a*                 | b**                | c                  | d = c/b              | e = b - c        |
| <b>MP1 — Nuclear Power, Fuel Cycle and Nuclear Science</b>                   |                    |                    |                    |                      |                  |
| Overall management, coordination and common activities                       | 3 484 098          | 3 458 550          | 3 581 556          | 103.6%               | (123 006)        |
| Nuclear Power                                                                | 9 528 906          | 9 446 307          | 9 000 336          | 95.3%                | 445 971          |
| Nuclear Fuel Cycle and Waste Management                                      | 9 540 390          | 9 462 419          | 8 638 951          | 91.3%                | 823 468          |
| Capacity Building and Nuclear Knowledge for Sustainable Energy Development   | 10 978 838         | 10 887 459         | 10 247 311         | 94.1%                | 640 148          |
| Nuclear Science                                                              | 9 258 347          | 9 207 987          | 9 140 018          | 99.3%                | 67 969           |
| <b>Total Major Programme 1</b>                                               | <b>42 790 579</b>  | <b>42 462 722</b>  | <b>40 608 172</b>  | <b>95.6%</b>         | <b>1 854 550</b> |
| <b>MP2 — Nuclear Techniques for Development and Environmental Protection</b> |                    |                    |                    |                      |                  |
| Overall management, coordination and common activities                       | 8 923 139          | 8 890 179          | 8 790 760          | 98.9%                | 99 419           |
| Food and Agriculture                                                         | 12 161 632         | 12 090 774         | 12 089 375         | 100.0%               | 1 399            |
| Human Health                                                                 | 9 099 476          | 9 032 658          | 8 932 831          | 98.9%                | 99 827           |
| Water Resources                                                              | 3 877 856          | 3 856 602          | 3 805 634          | 98.7%                | 50 968           |
| Marine Environment                                                           | 4 871 178          | 4 843 194          | 4 755 169          | 98.2%                | 88 025           |
| Radiochemistry and Radiation Technology                                      | 4 582 025          | 4 553 526          | 4 406 038          | 96.8%                | 147 488          |
| <b>Total Major Programme 2</b>                                               | <b>43 515 306</b>  | <b>43 266 933</b>  | <b>42 779 807</b>  | <b>98.9%</b>         | <b>487 126</b>   |
| <b>MP3 — Nuclear Safety and Security</b>                                     |                    |                    |                    |                      |                  |
| Overall management, coordination and common activities                       | 4 133 419          | 4 098 607          | 4 018 810          | 98.1%                | 79 797           |
| Incident and Emergency Preparedness and Response                             | 4 621 629          | 4 583 008          | 4 008 500          | 87.5%                | 574 508          |
| Safety of Nuclear Installations                                              | 11 093 051         | 10 986 117         | 10 518 938         | 95.7%                | 467 179          |
| Radiation and Transport Safety                                               | 7 921 420          | 7 852 610          | 8 004 615          | 101.9%               | (152 005)        |
| Radioactive Waste Management and Environmental Safety                        | 3 997 006          | 3 959 783          | 4 006 942          | 101.2%               | (47 159)         |
| Nuclear Security                                                             | 6 556 688          | 6 488 698          | 6 201 755          | 95.6%                | 286 943          |
| <b>Total Major Programme 3</b>                                               | <b>38 323 213</b>  | <b>37 968 823</b>  | <b>36 759 560</b>  | <b>96.8%</b>         | <b>1 209 263</b> |
| <b>MP4 — Nuclear Verification</b>                                            |                    |                    |                    |                      |                  |
| Overall management, coordination and common activities                       | 14 780 452         | 14 701 630         | 14 959 364         | 101.8%               | (257 734)        |
| Safeguards Implementation                                                    | 135 775 821        | 134 680 611        | 134 119 700        | 99.6%                | 560 911          |
| Other Verification Activities                                                | 3 100 992          | 3 062 592          | 3 150 290          | 102.9%               | (87 698)         |
| <b>Total Major Programme 4</b>                                               | <b>153 657 265</b> | <b>152 444 833</b> | <b>152 229 354</b> | <b>99.9%</b>         | <b>215 479</b>   |
| <b>MP5 — Policy, Management and Administration Services</b>                  |                    |                    |                    |                      |                  |
| Policy, Management and Administration Services                               | 84 287 568         | 83 844 462         | 83 820 518         | 100.0%               | 23 944           |
| <b>Total Major Programme 5</b>                                               | <b>84 287 568</b>  | <b>83 844 462</b>  | <b>83 820 518</b>  | <b>100.0%</b>        | <b>23 944</b>    |
| <b>MP6 — Management of Technical Cooperation for Development</b>             |                    |                    |                    |                      |                  |
| Management of Technical Cooperation for Development                          | 27 620 821         | 27 415 688         | 26 888 903         | 98.1%                | 526 785          |
| <b>Total Major Programme 6</b>                                               | <b>27 620 821</b>  | <b>27 415 688</b>  | <b>26 888 903</b>  | <b>98.1%</b>         | <b>526 785</b>   |
| <b>Total Operational Regular Budget</b>                                      | <b>390 194 752</b> | <b>387 403 461</b> | <b>383 086 314</b> | <b>98.9%</b>         | <b>4 317 147</b> |
| <b>Major Capital Investment Funding Requirements***</b>                      |                    |                    |                    |                      |                  |
| MP1 — Nuclear Power, Fuel Cycle and Nuclear Science                          | —                  | —                  | —                  | —                    | —                |
| MP2 — Nuclear Techniques for Development and Environmental Protection        | 1 525 500          | 1 522 144          | 2 773              | 0.2%                 | 1 519 371        |
| MP3 — Nuclear Safety and Security                                            | 305 100            | 305 100            | 18 146             | 5.9%                 | 286 954          |
| MP4 — Nuclear Verification                                                   | 1 017 000          | 1 017 000          | —                  | 0.0%                 | 1 017 000        |
| MP5 — Policy, Management and Administration Services                         | 3 254 400          | 3 254 400          | 1 622 068          | 49.8%                | 1 632 332        |
| MP6 — Management of Technical Cooperation for Development                    | —                  | —                  | —                  | —                    | —                |
| <b>Total Capital Regular Budget</b>                                          | <b>6 102 000</b>   | <b>6 098 644</b>   | <b>1 642 987</b>   | <b>26.9%</b>         | <b>4 455 657</b> |
| <b>Total Agency Programmes</b>                                               | <b>396 296 752</b> | <b>393 502 105</b> | <b>384 729 301</b> | <b>97.8%</b>         | <b>8 772 804</b> |
| Reimbursable Work for Others                                                 | 3 128 370          | 3 128 370          | 3 501 762          | 111.9%               | (373 392)        |
| <b>Total Regular Budget</b>                                                  | <b>399 425 122</b> | <b>396 630 475</b> | <b>388 231 063</b> | <b>97.9%</b>         | <b>8 399 412</b> |

\* General Conference resolution GC(65)/RES/4 of September 2021 — original budget at \$1/€1.

\*\* Original budget revalued at the United Nations operational average rate of exchange of €0.949 to \$1.

\*\*\* Additional information about the Major Capital Investment Fund can be found in note 39d of *The Agency's Financial Statements for 2022*.

**Table A2. Extrabudgetary regular programme fund resource utilization in 2022 by Programme and Major Programme (in euros)**

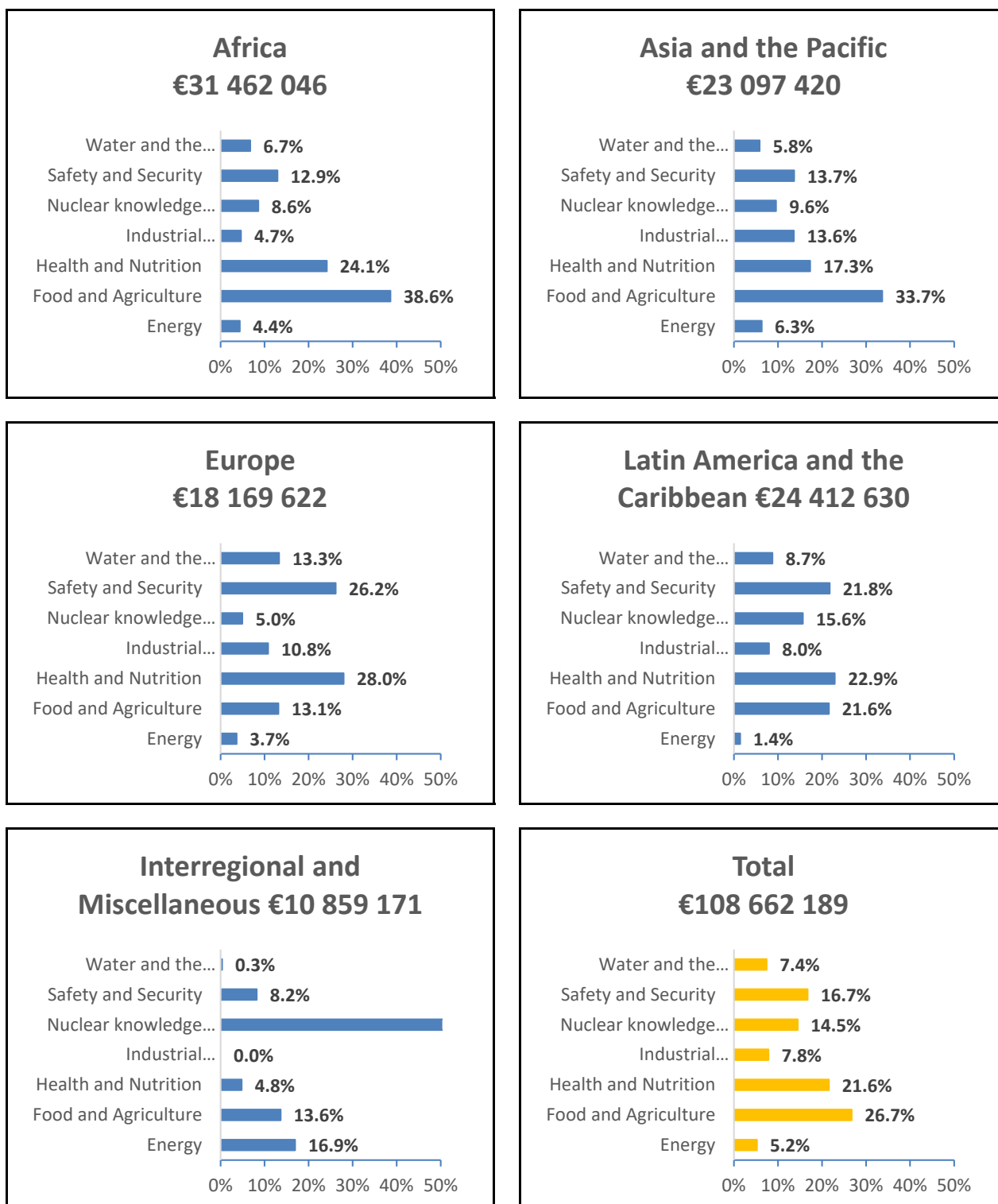
| Major Programme (MP)/Programme                                               | 2022 net expenditure |
|------------------------------------------------------------------------------|----------------------|
| <b>MP1 — Nuclear Power, Fuel Cycle and Nuclear Science</b>                   |                      |
| Overall management, coordination and common activities                       | 120 065              |
| Nuclear Power                                                                | 3 604 347            |
| Nuclear Fuel Cycle and Waste Management                                      | 1 407 368            |
| Capacity Building and Nuclear Knowledge for Sustainable Energy Development   | 3 652 490            |
| Nuclear Science                                                              | 530 637              |
| <b>Total Major Programme 1</b>                                               | <b>9 314 907</b>     |
| <b>MP2 — Nuclear Techniques for Development and Environmental Protection</b> |                      |
| Overall management, coordination and common activities                       | 17 416 225           |
| Food and Agriculture                                                         | 6 443 385            |
| Human Health                                                                 | 538 955              |
| Water Resources                                                              | 50 135               |
| Marine Environment                                                           | 1 568 378            |
| Radiochemistry and Radiation Technology                                      | 754 160              |
| <b>Total Major Programme 2</b>                                               | <b>26 771 238</b>    |
| <b>MP3 — Nuclear Safety and Security</b>                                     |                      |
| Overall management, coordination and common activities                       | 5 148 102            |
| Incident and Emergency Preparedness and Response                             | 1 940 632            |
| Safety of Nuclear Installations                                              | 5 654 460            |
| Radiation and Transport Safety                                               | 3 812 318            |
| Radioactive Waste Management and Environmental Safety                        | 1 524 984            |
| Nuclear Security                                                             | 27 054 324           |
| <b>Total Major Programme 3</b>                                               | <b>45 134 820</b>    |
| <b>MP4 — Nuclear Verification</b>                                            |                      |
| Overall management, coordination and common activities                       | 3 776 022            |
| Safeguards Implementation                                                    | 16 928 448           |
| Other Verification Activities                                                | 5 291 458            |
| <b>Total Major Programme 4</b>                                               | <b>25 995 928</b>    |
| <b>MP5 — Policy, Management and Administration Services</b>                  |                      |
| Policy, Management and Administration Services                               | 4 078 078            |
| <b>Total Major Programme 5</b>                                               | <b>4 078 078</b>     |
| <b>MP6 — Management of Technical Cooperation for Development</b>             |                      |
| Management of Technical Cooperation for Development                          | 1 146 436            |
| <b>Total Major Programme 6</b>                                               | <b>1 146 436</b>     |
| <b>Total extrabudgetary programme funds</b>                                  | <b>112 441 407</b>   |

Table A3(a). Disbursements (actuals) of the Technical Cooperation Fund by technical field and region in 2022

| Summary of all regions (in euros)                  |                   |                      |                   |                                 |                                 |                   |                    |
|----------------------------------------------------|-------------------|----------------------|-------------------|---------------------------------|---------------------------------|-------------------|--------------------|
| Technical field                                    | Africa            | Asia and the Pacific | Europe            | Latin America and the Caribbean | Interregional and miscellaneous | PACT <sup>a</sup> | Grand total        |
| Energy                                             | 1 373 652         | 1 457 527            | 663 575           | 344 636                         | 1 838 036                       | 0                 | 5 677 427          |
| Food and Agriculture                               | 12 138 922        | 7 780 754            | 2 389 047         | 5 266 274                       | 1 482 150                       | 0                 | 29 057 147         |
| Health and Nutrition                               | 7 591 498         | 3 999 481            | 5 078 926         | 5 591 132                       | 521 363                         | 661 300           | 23 443 700         |
| Industrial Applications/<br>Radiation Technology   | 1 464 353         | 3 142 070            | 1 965 092         | 1 946 476                       | 0                               | 0                 | 8 517 990          |
| Nuclear knowledge<br>development and<br>management | 2 703 878         | 2 209 164            | 900 509           | 3 819 789                       | 6 086 190                       | 0                 | 15 719 530         |
| Safety and Security                                | 4 068 968         | 3 159 224            | 4 754 042         | 5 310 763                       | 893 649                         | 0                 | 18 186 646         |
| Water and the<br>Environment                       | 2 120 776         | 1 349 201            | 2 418 431         | 2 133 559                       | 37 782                          | 0                 | 8 059 749          |
| <b>Grand Total</b>                                 | <b>31 462 046</b> | <b>23 097 420</b>    | <b>18 169 622</b> | <b>24 412 630</b>               | <b>10 859 171</b>               | <b>661 300</b>    | <b>108 662 189</b> |

<sup>a</sup> PACT: Programme of Action for Cancer Therapy.

Table A3(b). Graphical representation of the information in Table A3(a)



Note: See Table A3(a) for the full titles of the technical fields.

Table A4. Amount of nuclear material under Agency safeguards at the end of 2022 by type of agreement

| Nuclear material                                                                          | Comprehensive safeguards agreement <sup>a</sup> | INFCIRC/66-type agreement | Voluntary offer agreement | Quantity in significant quantities (SQs) |
|-------------------------------------------------------------------------------------------|-------------------------------------------------|---------------------------|---------------------------|------------------------------------------|
| Plutonium <sup>b</sup> contained in irradiated fuel and in fuel elements in reactor cores | 154 802                                         | 3 843                     | 22 628                    | 181 273                                  |
| Separated plutonium outside reactor cores                                                 | 1 232                                           | 5                         | 10 886                    | 12 123                                   |
| High enriched uranium (equal to or greater than 20% U-235)                                | 154                                             | 2                         | 0                         | 156                                      |
| Low enriched uranium (less than 20% U-235)                                                | 19 221                                          | 403                       | 993                       | 20 617                                   |
| Source material <sup>c</sup> (natural and depleted uranium and thorium)                   | 12 186                                          | 1 709                     | 2 672                     | 16 567                                   |
| U-233                                                                                     | 18                                              | 0                         | 0                         | 18                                       |
| <b>Total SQs of nuclear material</b>                                                      | <b>187 613</b>                                  | <b>5 962</b>              | <b>37 179</b>             | <b>230 754</b>                           |

**Amount of heavy water under Agency safeguards at the end of 2022 by type of agreement**

| Non-nuclear material <sup>d</sup> | Comprehensive safeguards agreement | INFCIRC/66-type agreement | Voluntary offer agreement | Quantity in tonnes       |
|-----------------------------------|------------------------------------|---------------------------|---------------------------|--------------------------|
| <b>Heavy water (tonnes)</b>       |                                    | <b>414.1</b>              |                           | <b>414.8<sup>e</sup></b> |

<sup>a</sup> Includes nuclear material under Agency safeguards in Taiwan, China; excludes nuclear material in the Democratic People's Republic of Korea.

<sup>b</sup> The quantity includes an estimated amount (9 000 SQs) of plutonium in fuel elements loaded into reactor cores and plutonium in other irradiated fuel, which has not yet been reported to the Agency under agreed reporting procedures.

<sup>c</sup> This table does not include material within the terms of subparagraphs 34(a) and 34(b) of INFCIRC/153 (Corrected).

<sup>d</sup> Non-nuclear material subject to Agency safeguards under INFCIRC/66/Rev.2-type agreements.

<sup>e</sup> Includes 0.7 tonnes of heavy water under Agency safeguards in Taiwan, China.

Table A5. Number of facilities and material balance areas outside facilities under Agency safeguards during 2022

| Type                                                                        | Comprehensive safeguards agreement <sup>a</sup> | INFCIRC/66-type agreement <sup>b</sup> | Voluntary offer agreement | Total       |
|-----------------------------------------------------------------------------|-------------------------------------------------|----------------------------------------|---------------------------|-------------|
| Power reactors                                                              | 248                                             | 18                                     | 1                         | 267         |
| Research reactors and critical assemblies                                   | 143                                             | 3                                      | 0                         | 146         |
| Conversion plants                                                           | 17                                              | 0                                      | 0                         | 17          |
| Fuel fabrication plants                                                     | 37                                              | 3                                      | 1                         | 41          |
| Reprocessing plants                                                         | 10                                              | 0                                      | 1                         | 11          |
| Enrichment plants                                                           | 17                                              | 0                                      | 3                         | 20          |
| Separate storage facilities                                                 | 138                                             | 2                                      | 4                         | 144         |
| Other facilities                                                            | 76                                              | 0                                      | 0                         | 76          |
| <b>Facility subtotals</b>                                                   | <b>686</b>                                      | <b>26</b>                              | <b>10</b>                 | <b>722</b>  |
| Material balance areas containing locations outside facilities <sup>c</sup> | 628                                             | 1                                      | 2                         | 631         |
| <b>Total</b>                                                                | <b>1314</b>                                     | <b>27</b>                              | <b>12</b>                 | <b>1353</b> |

<sup>a</sup> Covering safeguards agreements pursuant to the Treaty on the Non-Proliferation of Nuclear Weapons and/or the Treaty of Tlatelolco and other comprehensive safeguards agreements; includes facilities in Taiwan, China.

<sup>b</sup> Covering facilities in India, Israel and Pakistan.

<sup>c</sup> Includes 79 material balance areas in States with amended small quantities protocols.



**Table A6. Conclusion of safeguards agreements, additional protocols and small quantities protocols (as of 31 December 2022)**

| State <sup>a</sup>                           | Small quantities protocols <sup>b</sup> | Safeguards agreements <sup>c</sup> | INFCIRC | Additional protocols   |
|----------------------------------------------|-----------------------------------------|------------------------------------|---------|------------------------|
| Afghanistan                                  | Amended: 28 Jan. 2016                   | In force: 20 Feb. 1978             | 257     | In force: 19 Jul. 2005 |
| Albania <sup>1</sup>                         |                                         | In force: 25 Mar. 1988             | 359     | In force: 3 Nov. 2010  |
| Algeria                                      |                                         | In force: 7 Jan. 1997              | 531     | Signed: 16 Feb. 2018   |
| Andorra                                      | Amended: 24 Apr. 2013                   | In force: 18 Oct. 2010             | 808     | In force: 19 Dec. 2011 |
| Angola                                       | In force: 28 Apr. 2010                  | In force: 28 Apr. 2010             | 800     | In force: 28 Apr. 2010 |
| Antigua and Barbuda <sup>2</sup>             | Amended: 5 Mar. 2012                    | In force: 9 Sep. 1996              | 528     | In force: 15 Nov. 2013 |
| Argentina <sup>3</sup>                       |                                         | In force: 4 Mar. 1994              | 435     |                        |
| Armenia                                      |                                         | In force: 5 May 1994               | 455     | In force: 28 Jun. 2004 |
| Australia                                    |                                         | In force: 10 Jul. 1974             | 217     | In force: 12 Dec. 1997 |
| Austria <sup>4</sup>                         |                                         | Accession: 31 Jul. 1996            | 193     | In force: 30 Apr. 2004 |
| Azerbaijan                                   |                                         | In force: 29 Apr. 1999             | 580     | In force: 29 Nov. 2000 |
| Bahamas <sup>2</sup>                         | Amended: 25 Jul. 2007                   | In force: 12 Sep. 1997             | 544     |                        |
| Bahrain                                      | In force: 10 May 2009                   | In force: 10 May 2009              | 767     | In force: 20 Jul. 2011 |
| Bangladesh                                   |                                         | In force: 11 Jun. 1982             | 301     | In force: 30 Mar. 2001 |
| Barbados <sup>2</sup>                        | X                                       | In force: 14 Aug. 1996             | 527     |                        |
| Belarus                                      |                                         | In force: 2 Aug. 1995              | 495     | Signed: 15 Nov. 2005   |
| Belgium                                      |                                         | In force: 21 Feb. 1977             | 193     | In force: 30 Apr. 2004 |
| Belize <sup>5</sup>                          | Amended: 21 Jun. 2021                   | In force: 21 Jan. 1997             | 532     |                        |
| Benin                                        | In force: 17 Sep. 2019                  | In force: 17 Sep. 2019             | 930     | In force: 17 Sep. 2019 |
| Bhutan                                       | X                                       | In force: 24 Oct. 1989             | 371     |                        |
| Bolivia, Plurinational State of <sup>2</sup> | X                                       | In force: 6 Feb. 1995              | 465     | Signed: 18 Sep. 2019   |
| Bosnia and Herzegovina                       |                                         | In force: 4 Apr. 2013              | 851     | In force: 3 Jul. 2013  |
| Botswana                                     |                                         | In force: 24 Aug. 2006             | 694     | In force: 24 Aug. 2006 |
| Brazil <sup>6</sup>                          |                                         | In force: 4 Mar. 1994              | 435     |                        |
| Brunei Darussalam                            | Amended: 2 Sep. 2021                    | In force: 4 Nov. 1987              | 365     |                        |
| Bulgaria <sup>7</sup>                        |                                         | Accession: 1 May 2009              | 193     | Accession: 1 May 2009  |
| Burkina Faso                                 | Amended: 18 Feb. 2008                   | In force: 17 Apr. 2003             | 618     | In force: 17 Apr. 2003 |

| State <sup>a</sup>                    | Small quantities protocols <sup>b</sup> | Safeguards agreements <sup>c</sup>              | INFCIRC    | Additional protocols                             |
|---------------------------------------|-----------------------------------------|-------------------------------------------------|------------|--------------------------------------------------|
| Burundi                               | In force: 27 Sep. 2007                  | In force: 27 Sep. 2007                          | 719        | In force: 27 Sep. 2007                           |
| Cabo Verde                            | In force: 7 Sep. 2022                   | In force: 7 Sep. 2022                           | 1048       | In force: 7 Sep. 2022                            |
| Cambodia                              | Amended: 16 Jul. 2014                   | In force: 17 Dec. 1999                          | 586        | In force: 24 Apr. 2015                           |
| Cameroon                              | Amended: 15 Jul. 2019                   | In force: 17 Dec. 2004                          | 641        | In force: 29 Sep. 2016                           |
| Canada                                |                                         | In force: 21 Feb. 1972                          | 164        | In force: 8 Sep. 2000                            |
| Central African Republic              | In force: 7 Sep. 2009                   | In force: 7 Sep. 2009                           | 777        | In force: 7 Sep. 2009                            |
| Chad                                  | In force: 13 May 2010                   | In force: 13 May 2010                           | 802        | In force: 13 May 2010                            |
| Chile <sup>8</sup>                    |                                         | In force: 5 Apr. 1995                           | 476        | In force: 3 Nov. 2003                            |
| China                                 |                                         | In force: 18 Sep. 1989                          | 369*       | In force: 28 Mar. 2002                           |
| Colombia <sup>8</sup>                 |                                         | In force: 22 Dec. 1982                          | 306        | In force: 5 Mar. 2009                            |
| Comoros                               | In force: 20 Jan. 2009                  | In force: 20 Jan. 2009                          | 752        | In force: 20 Jan. 2009                           |
| Congo                                 | In force: 28 Oct. 2011                  | In force: 28 Oct. 2011                          | 831        | In force: 28 Oct. 2011                           |
| Costa Rica <sup>2</sup>               | Amended: 12 Jan. 2007                   | In force: 22 Nov. 1979                          | 278        | In force: 17 Jun. 2011                           |
| Côte d'Ivoire                         |                                         | In force: 8 Sep. 1983                           | 309        | In force: 5 May 2016                             |
| Croatia <sup>9</sup>                  |                                         | Accession: 1 Apr. 2017                          | 193        | Accession: 1 Apr. 2017                           |
| Cuba <sup>2</sup>                     |                                         | In force: 3 Jun. 2004                           | 633        | In force: 3 Jun. 2004                            |
| Cyprus <sup>10</sup>                  |                                         | Accession: 1 May 2008                           | 193        | Accession: 1 May 2008                            |
| Czech Republic <sup>11</sup>          |                                         | Accession: 1 Oct. 2009                          | 193        | Accession: 1 Oct. 2009                           |
| Democratic Republic of the Congo      |                                         | In force: 9 Nov. 1972                           | 183        | In force: 9 Apr. 2003                            |
| Denmark <sup>12</sup>                 |                                         | In force: 1 Mar. 1972<br>In force: 21 Feb. 1977 | 176<br>193 | In force: 22 Mar. 2013<br>In force: 30 Apr. 2004 |
| Djibouti                              | In force: 26 May 2015                   | In force: 26 May 2015                           | 884        | In force: 26 May 2015                            |
| Dominica <sup>5</sup>                 | X                                       | In force: 3 May 1996                            | 513        |                                                  |
| Dominican Republic <sup>2</sup>       | Amended: 11 Oct. 2006                   | In force: 11 Oct. 1973                          | 201        | In force: 5 May 2010                             |
| Democratic People's Republic of Korea |                                         | In force: 10 Apr. 1992                          | 403        |                                                  |
| Ecuador <sup>2</sup>                  | Amended: 7 Apr. 2006                    | In force: 10 Mar. 1975                          | 231        | In force: 24 Oct. 2001                           |
| Egypt                                 |                                         | In force: 30 Jun. 1982                          | 302        |                                                  |
| El Salvador <sup>2</sup>              | Amended: 10 Jun. 2011                   | In force: 22 Apr. 1975                          | 232        | In force: 24 May 2004                            |

| State <sup>a</sup>        | Small quantities protocols <sup>b</sup> | Safeguards agreements <sup>c</sup>                             | INFCIRC     | Additional protocols        |
|---------------------------|-----------------------------------------|----------------------------------------------------------------|-------------|-----------------------------|
| <i>Equatorial Guinea</i>  | <i>Approved: 13 Jun. 1986</i>           | <i>Approved: 13 Jun. 1986</i>                                  |             |                             |
| Eritrea                   | In force: 20 Apr. 2021                  | In force: 20 Apr. 2021                                         | 960         | In force: 20 Apr. 2021      |
| Estonia <sup>13</sup>     |                                         | Accession: 1 Dec. 2005                                         | 193         | Accession: 1 Dec. 2005      |
| Eswatini                  | Amended: 23 Jul. 2010                   | In force: 28 Jul. 1975                                         | 227         | In force: 8 Sep. 2010       |
| Ethiopia                  | Amended: 2 Jul. 2019                    | In force: 2 Dec. 1977                                          | 261         | In force: 18 Sep. 2019      |
| Fiji                      | X                                       | In force: 22 Mar. 1973                                         | 192         | In force: 14 Jul. 2006      |
| Finland <sup>14</sup>     |                                         | Accession: 1 Oct. 1995                                         | 193         | In force: 30 Apr. 2004      |
| France                    | Amended: 25 Feb. 2019                   | In force: 12 Sep. 1981<br>In force: 26 Oct. 2007 <sup>15</sup> | 290*<br>718 | In force: 30 Apr. 2004      |
| Gabon                     | Amended: 30 Oct. 2013                   | In force: 25 Mar. 2010                                         | 792         | In force: 25 Mar. 2010      |
| Gambia                    | Amended: 17 Oct. 2011                   | In force: 8 Aug. 1978                                          | 277         | In force: 18 Oct. 2011      |
| Georgia                   |                                         | In force: 3 Jun. 2003                                          | 617         | In force: 3 Jun. 2003       |
| Germany <sup>16</sup>     |                                         | In force: 21 Feb. 1977                                         | 193         | In force: 30 Apr. 2004      |
| Ghana                     |                                         | In force: 17 Feb. 1975                                         | 226         | In force: 11 Jun. 2004      |
| Greece <sup>17</sup>      |                                         | Accession: 17 Dec. 1981                                        | 193         | In force: 30 Apr. 2004      |
| Grenada <sup>2</sup>      | X                                       | In force: 23 Jul. 1996                                         | 525         |                             |
| Guatemala <sup>2</sup>    | Amended: 26 Apr. 2011                   | In force: 1 Feb. 1982                                          | 299         | In force: 28 May 2008       |
| <i>Guinea</i>             | <i>Signed: 13 Dec. 2011</i>             | <i>Signed: 13 Dec. 2011</i>                                    |             | <i>Signed: 13 Dec. 2011</i> |
| Guinea-Bissau             | In force: 23 Jun. 2022                  | In force: 23 Jun. 2022                                         | 1005        | In force: 23 Jun. 2022      |
| Guyana <sup>2</sup>       | X                                       | In force: 23 May 1997                                          | 543         |                             |
| Haiti <sup>2</sup>        | Amended: 22 Jan. 2020                   | In force: 9 Mar. 2006                                          | 681         | In force: 9 Mar. 2006       |
| Holy See                  | Amended: 11 Sep. 2006                   | In force: 1 Aug. 1972                                          | 187         | In force: 24 Sep. 1998      |
| Honduras <sup>2</sup>     | Amended: 20 Sep. 2007                   | In force: 18 Apr. 1975                                         | 235         | In force: 17 Nov. 2017      |
| Hungary <sup>18</sup>     |                                         | Accession: 1 Jul. 2007                                         | 193         | Accession: 1 Jul. 2007      |
| Iceland                   | Amended: 15 Mar. 2010                   | In force: 16 Oct. 1974                                         | 215         | In force: 12 Sep. 2003      |
| <b>India<sup>19</sup></b> |                                         | In force: 30 Sep. 1971                                         | 211         |                             |
|                           |                                         | In force: 17 Nov. 1977                                         | 260         |                             |
|                           |                                         | In force: 27 Sep. 1988                                         | 360         |                             |
|                           |                                         | In force: 11 Oct. 1989                                         | 374         |                             |
|                           |                                         | In force: 1 Mar. 1994                                          | 433         |                             |
|                           |                                         | In force: 11 May 2009                                          | 754         | In force: 25 Jul. 2014      |
| Indonesia                 |                                         | In force: 14 Jul. 1980                                         | 283         | In force: 29 Sep. 1999      |

| State <sup>a</sup>                      | Small quantities protocols <sup>b</sup> | Safeguards agreements <sup>c</sup> | INFCIRC   | Additional protocols   |
|-----------------------------------------|-----------------------------------------|------------------------------------|-----------|------------------------|
| Iran, Islamic Republic of <sup>20</sup> |                                         | In force: 15 May 1974              | 214       | Signed: 18 Dec. 2003   |
| Iraq                                    |                                         | In force: 29 Feb. 1972             | 172       | In force: 10 Oct. 2012 |
| Ireland                                 |                                         | In force: 21 Feb. 1977             | 193       | In force: 30 Apr. 2004 |
| <b>Israel</b>                           |                                         | In force: 4 Apr. 1975              | 249/Add.1 |                        |
| Italy                                   |                                         | In force: 21 Feb. 1977             | 193       | In force: 30 Apr. 2004 |
| Jamaica <sup>2</sup>                    |                                         | In force: 6 Nov. 1978              | 265       | In force: 19 Mar. 2003 |
| Japan                                   |                                         | In force: 2 Dec. 1977              | 255       | In force: 16 Dec. 1999 |
| Jordan                                  |                                         | In force: 21 Feb. 1978             | 258       | In force: 28 Jul. 1998 |
| Kazakhstan                              |                                         | In force: 11 Aug. 1995             | 504       | In force: 9 May 2007   |
| Kenya                                   | In force: 18 Sep. 2009                  | In force: 18 Sep. 2009             | 778       | In force: 18 Sep. 2009 |
| Kiribati                                | X                                       | In force: 19 Dec. 1990             | 390       | Signed: 9 Nov. 2004    |
| Korea, Republic of                      |                                         | In force: 14 Nov. 1975             | 236       | In force: 19 Feb. 2004 |
| Kuwait                                  | Amended: 26 Jul. 2013                   | In force: 7 Mar. 2002              | 607       | In force: 2 Jun. 2003  |
| Kyrgyzstan                              | X                                       | In force: 3 Feb. 2004              | 629       | In force: 10 Nov. 2011 |
| Lao People's Democratic Republic        | Amended: 24 Jun. 2022                   | In force: 5 Apr. 2001              | 599       | Signed: 5 Nov. 2014    |
| Latvia <sup>21</sup>                    |                                         | Accession: 1 Oct. 2008             | 193       | Accession: 1 Oct. 2008 |
| Lebanon                                 | Amended: 5 Sep. 2007                    | In force: 5 Mar. 1973              | 191       |                        |
| Lesotho                                 | Amended: 8 Sep. 2009                    | In force: 12 Jun. 1973             | 199       | In force: 26 Apr. 2010 |
| Liberia                                 | In force: 10 Dec. 2018                  | In force: 10 Dec. 2018             | 927       | In force: 10 Dec. 2018 |
| Libya                                   |                                         | In force: 8 Jul. 1980              | 282       | In force: 11 Aug. 2006 |
| Liechtenstein                           |                                         | In force: 4 Oct. 1979              | 275       | In force: 25 Nov. 2015 |
| Lithuania <sup>22</sup>                 |                                         | Accession: 1 Jan. 2008             | 193       | Accession: 1 Jan. 2008 |
| Luxembourg                              |                                         | In force: 21 Feb. 1977             | 193       | In force: 30 Apr. 2004 |
| Madagascar                              | Amended: 29 May 2008                    | In force: 14 Jun. 1973             | 200       | In force: 18 Sep. 2003 |
| Malawi                                  | Amended: 29 Feb. 2008                   | In force: 3 Aug. 1992              | 409       | In force: 26 Jul. 2007 |
| Malaysia                                |                                         | In force: 29 Feb. 1972             | 182       | Signed: 22 Nov. 2005   |
| Maldives                                | Amended: 21 May 2021                    | In force: 2 Oct. 1977              | 253       |                        |
| Mali                                    | Amended: 18 Apr. 2006                   | In force: 12 Sep. 2002             | 615       | In force: 12 Sep. 2002 |

| State <sup>a</sup>              | Small quantities protocols <sup>b</sup> | Safeguards agreements <sup>c</sup>                                                                                                                                                                                                                           | INFCIRC                                                           | Additional protocols   |
|---------------------------------|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|------------------------|
| Malta <sup>23</sup>             |                                         | Accession: 1 Jul. 2007                                                                                                                                                                                                                                       | 193                                                               | Accession: 1 Jul. 2007 |
| Marshall Islands                |                                         | In force: 3 May 2005                                                                                                                                                                                                                                         | 653                                                               | In force: 3 May 2005   |
| Mauritania                      | Amended: 20 Mar. 2013                   | In force: 10 Dec. 2009                                                                                                                                                                                                                                       | 788                                                               | In force: 10 Dec. 2009 |
| Mauritius                       | Amended: 26 Sep. 2008                   | In force: 31 Jan. 1973                                                                                                                                                                                                                                       | 190                                                               | In force: 17 Dec. 2007 |
| Mexico <sup>24</sup>            |                                         | In force: 14 Sep. 1973                                                                                                                                                                                                                                       | 197                                                               | In force: 4 Mar. 2011  |
| Micronesia, Federated States of | In force: 1 Sep. 2021                   | In force: 1 Sep. 2021                                                                                                                                                                                                                                        | 962                                                               |                        |
| Monaco                          | Amended: 27 Nov. 2008                   | In force: 13 Jun. 1996                                                                                                                                                                                                                                       | 524                                                               | In force: 30 Sep. 1999 |
| Mongolia                        | X                                       | In force: 5 Sep. 1972                                                                                                                                                                                                                                        | 188                                                               | In force: 12 May 2003  |
| Montenegro                      | In force: 4 Mar. 2011                   | In force: 4 Mar. 2011                                                                                                                                                                                                                                        | 814                                                               | In force: 4 Mar. 2011  |
| Morocco                         |                                         | In force: 18 Feb. 1975                                                                                                                                                                                                                                       | 228                                                               | In force: 21 Apr. 2011 |
| Mozambique                      | In force: 1 Mar. 2011                   | In force: 1 Mar. 2011                                                                                                                                                                                                                                        | 813                                                               | In force: 1 Mar. 2011  |
| Myanmar                         | X                                       | In force: 20 Apr. 1995                                                                                                                                                                                                                                       | 477                                                               | Signed: 17 Sep. 2013   |
| Namibia                         | Amended: 4 Jul. 2022                    | In force: 15 Apr. 1998                                                                                                                                                                                                                                       | 551                                                               | In force: 20 Feb. 2012 |
| Nauru                           | X                                       | In force: 13 Apr. 1984                                                                                                                                                                                                                                       | 317                                                               |                        |
| Nepal                           | X                                       | In force: 22 Jun. 1972                                                                                                                                                                                                                                       | 186                                                               |                        |
| Netherlands                     | X                                       | In force: 5 Jun. 1975 <sup>15</sup><br>In force: 21 Feb. 1977                                                                                                                                                                                                | 229<br>193                                                        | In force: 30 Apr. 2004 |
| New Zealand <sup>25</sup>       | Amended: 24 Feb. 2014                   | In force: 29 Feb. 1972                                                                                                                                                                                                                                       | 185                                                               | In force: 24 Sep. 1998 |
| Nicaragua <sup>2</sup>          | Amended: 12 Jun. 2009                   | In force: 29 Dec. 1976                                                                                                                                                                                                                                       | 246                                                               | In force: 18 Feb. 2005 |
| Niger                           |                                         | In force: 16 Feb. 2005                                                                                                                                                                                                                                       | 664                                                               | In force: 2 May 2007   |
| Nigeria                         |                                         | In force: 29 Feb. 1988                                                                                                                                                                                                                                       | 358                                                               | In force: 4 Apr. 2007  |
| North Macedonia                 | Amended: 9 Jul. 2009                    | In force: 16 Apr. 2002                                                                                                                                                                                                                                       | 610                                                               | In force: 11 May 2007  |
| Norway                          |                                         | In force: 1 Mar. 1972                                                                                                                                                                                                                                        | 177                                                               | In force: 16 May 2000  |
| Oman                            | X                                       | In force: 5 Sep. 2006                                                                                                                                                                                                                                        | 691                                                               |                        |
| Pakistan                        |                                         | In force: 5 Mar. 1962<br>In force: 17 Jun. 1968<br>In force: 17 Oct. 1969<br>In force: 18 Mar. 1976<br>In force: 2 Mar. 1977<br>In force: 10 Sep. 1991<br>In force: 24 Feb. 1993<br>In force: 22 Feb. 2007<br>In force: 15 Apr. 2011<br>In force: 3 May 2017 | 34<br>116<br>135<br>239<br>248<br>393<br>418<br>705<br>816<br>920 |                        |

| State <sup>a</sup>                            | Small quantities protocols <sup>b</sup> | Safeguards agreements <sup>c</sup> | INFCIRC | Additional protocols          |
|-----------------------------------------------|-----------------------------------------|------------------------------------|---------|-------------------------------|
| Palau                                         | Amended: 15 Mar. 2006                   | In force: 13 May 2005              | 650     | In force: 13 May 2005         |
| Panama <sup>8</sup>                           | Amended: 4 Mar. 2011                    | In force: 23 Mar. 1984             | 316     | In force: 11 Dec. 2001        |
| Papua New Guinea                              | Amended: 6 Feb. 2019                    | In force: 13 Oct. 1983             | 312     |                               |
| Paraguay <sup>2</sup>                         | Amended: 17 Jul. 2018                   | In force: 20 Mar. 1979             | 279     | In force: 15 Sep. 2004        |
| Peru <sup>2</sup>                             |                                         | In force: 1 Aug. 1979              | 273     | In force: 23 Jul. 2001        |
| Philippines                                   |                                         | In force: 16 Oct. 1974             | 216     | In force: 26 Feb. 2010        |
| Poland <sup>26</sup>                          |                                         | Accession: 1 Mar. 2007             | 193     | Accession: 1 Mar. 2007        |
| Portugal <sup>27</sup>                        |                                         | Accession: 1 Jul. 1986             | 193     | In force: 30 Apr. 2004        |
| Qatar                                         | In force: 21 Jan. 2009                  | In force: 21 Jan. 2009             | 747     |                               |
| Republic of Moldova                           | Amended: 1 Sep. 2011                    | In force: 17 May 2006              | 690     | In force: 1 Jun. 2012         |
| Romania <sup>28</sup>                         |                                         | Accession: 1 May 2010              | 193     | Accession: 1 May 2010         |
| Russian Federation                            |                                         | In force: 10 Jun. 1985             | 327*    | In force: 16 Oct. 2007        |
| Rwanda                                        | In force: 17 May 2010                   | In force: 17 May 2010              | 801     | In force: 17 May 2010         |
| Saint Kitts and Nevis <sup>5</sup>            | Amended: 19 Aug. 2016                   | In force: 7 May 1996               | 514     | In force: 19 May 2014         |
| Saint Lucia <sup>5</sup>                      | Amended: 23 Nov. 2021                   | In force: 2 Feb. 1990              | 379     |                               |
| Saint Vincent and the Grenadines <sup>5</sup> | X                                       | In force: 8 Jan. 1992              | 400     |                               |
| Samoa                                         | X                                       | In force: 22 Jan. 1979             | 268     |                               |
| San Marino                                    | Amended: 13 May 2011                    | In force: 21 Sep. 1998             | 575     |                               |
| <i>Sao Tome and Principe</i>                  | <i>Approved: 21 Nov. 2019</i>           | <i>Approved: 21 Nov. 2019</i>      |         | <i>Approved: 21 Nov. 2019</i> |
| Saudi Arabia                                  | X                                       | In force: 13 Jan. 2009             | 746     |                               |
| Senegal                                       | Amended: 6 Jan. 2010                    | In force: 14 Jan. 1980             | 276     | In force: 24 Jul. 2017        |
| Serbia <sup>29</sup>                          |                                         | In force: 28 Dec. 1973             | 204     | In force: 17 Sep. 2018        |
| Seychelles                                    | Amended: 31 Oct. 2006                   | In force: 19 Jul. 2004             | 635     | In force: 13 Oct. 2004        |
| Sierra Leone                                  | X                                       | In force: 4 Dec. 2009              | 787     | Signed: 31 Oct. 2022          |
| Singapore                                     | Amended: 31 Mar. 2008                   | In force: 18 Oct. 1977             | 259     | In force: 31 Mar. 2008        |
| Slovakia <sup>30</sup>                        |                                         | Accession: 1 Dec. 2005             | 193     | Accession: 1 Dec. 2005        |
| Slovenia <sup>31</sup>                        |                                         | Accession: 1 Sep. 2006             | 193     | Accession: 1 Sep. 2006        |
| Solomon Islands                               | X                                       | In force: 17 Jun. 1993             | 420     |                               |

| State <sup>a</sup>               | Small quantities protocols <sup>b</sup> | Safeguards agreements <sup>c</sup>                                                                                | INFCIRC     | Additional protocols                 |
|----------------------------------|-----------------------------------------|-------------------------------------------------------------------------------------------------------------------|-------------|--------------------------------------|
| <i>Somalia</i>                   |                                         |                                                                                                                   |             |                                      |
| South Africa                     |                                         | In force: 16 Sep. 1991                                                                                            | 394         | In force: 13 Sep. 2002               |
| Spain                            |                                         | Accession: 5 Apr. 1989                                                                                            | 193         | In force: 30 Apr. 2004               |
| Sri Lanka                        |                                         | In force: 6 Aug. 1984                                                                                             | 320         | Approved: 12 Sep. 2018               |
| State of Palestine <sup>32</sup> | In force: 7 Sep. 2022                   | In force: 7 Sep. 2022                                                                                             | 1050        |                                      |
| Sudan                            | Amended: 19 Feb. 2021                   | In force: 7 Jan. 1977                                                                                             | 245         |                                      |
| Suriname <sup>2</sup>            | Amended: 31 Oct. 2022                   | In force: 2 Feb. 1979                                                                                             | 269         |                                      |
| Sweden <sup>33</sup>             |                                         | Accession: 1 Jun. 1995                                                                                            | 193         | In force: 30 Apr. 2004               |
| Switzerland                      |                                         | In force: 6 Sep. 1978                                                                                             | 264         | In force: 1 Feb. 2005                |
| Syrian Arab Republic             |                                         | In force: 18 May 1992                                                                                             | 407         |                                      |
| Tajikistan                       |                                         | In force: 14 Dec. 2004                                                                                            | 639         | In force: 14 Dec. 2004               |
| Thailand                         |                                         | In force: 16 May 1974                                                                                             | 241         | In force: 17 Nov. 2017               |
| <i>Timor-Leste</i>               | <i>Signed: 6 Oct. 2009</i>              | <i>Signed: 6 Oct. 2009</i>                                                                                        |             | <i>Signed: 6 Oct. 2009</i>           |
| Togo                             | Amended: 8 Oct. 2015                    | In force: 18 Jul. 2012                                                                                            | 840         | In force: 18 Jul. 2012               |
| Tonga                            | Amended: 3 Apr. 2018                    | In force: 18 Nov. 1993                                                                                            | 426         |                                      |
| Trinidad and Tobago <sup>2</sup> | X                                       | In force: 4 Nov. 1992                                                                                             | 414         |                                      |
| Tunisia                          |                                         | In force: 13 Mar. 1990                                                                                            | 381         | Signed: 24 May 2005                  |
| Türkiye                          |                                         | In force: 1 Sep. 1981                                                                                             | 295         | In force: 17 Jul. 2001               |
| Turkmenistan                     |                                         | In force: 3 Jan. 2006                                                                                             | 673         | In force: 3 Jan. 2006                |
| Tuvalu                           | Amended: 1 Dec. 2022                    | In force: 15 Mar. 1991                                                                                            | 391         |                                      |
| Uganda                           | Amended: 24 Jun. 2009                   | In force: 14 Feb. 2006                                                                                            | 674         | In force: 14 Feb. 2006               |
| Ukraine                          |                                         | In force: 22 Jan. 1998                                                                                            | 550         | In force: 24 Jan. 2006               |
| United Arab Emirates             |                                         | In force: 9 Oct. 2003                                                                                             | 622         | In force: 20 Dec. 2010               |
| United Kingdom                   | Signed: 6 Jan. 1993                     | In force: 14 Dec. 1972 <sup>34</sup><br>Signed: 6 Jan. 1993 <sup>15</sup><br>In force: 31 Dec. 2020 <sup>35</sup> | 175<br>951* | In force: 31 Dec. 2020 <sup>35</sup> |
| United Republic of Tanzania      | Amended: 10 Jun. 2009                   | In force: 7 Feb. 2005                                                                                             | 643         | In force: 7 Feb. 2005                |
| United States of America         | Amended: 3 Jul. 2018                    | In force: 9 Dec. 1980<br>In force: 6 Apr. 1989 <sup>15</sup>                                                      | 288*<br>366 | In force: 6 Jan. 2009                |
| Uruguay <sup>2</sup>             |                                         | In force: 17 Sep. 1976                                                                                            | 157         | In force: 30 Apr. 2004               |
| Uzbekistan                       |                                         | In force: 8 Oct. 1994                                                                                             | 508         | In force: 21 Dec. 1998               |

| State <sup>a</sup>                             | Small quantities protocols <sup>b</sup> | Safeguards agreements <sup>c</sup> | INFCIRC | Additional protocols   |
|------------------------------------------------|-----------------------------------------|------------------------------------|---------|------------------------|
| Vanuatu                                        | In force: 21 May 2013                   | In force: 21 May 2013              | 852     | In force: 21 May 2013  |
| Venezuela, Bolivarian Republic of <sup>2</sup> |                                         | In force: 11 Mar. 1982             | 300     |                        |
| Viet Nam                                       |                                         | In force: 23 Feb. 1990             | 376     | In force: 17 Sep. 2012 |
| Yemen                                          | X                                       | In force: 14 Aug. 2002             | 614     |                        |
| Zambia                                         | X                                       | In force: 22 Sep. 1994             | 456     | Signed: 13 May 2009    |
| Zimbabwe                                       | Amended: 31 Aug. 2011                   | In force: 26 Jun. 1995             | 483     | In force: 21 Sep. 2021 |

### Key

**Bold** States not party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) whose safeguards agreements are of INFCIRC/66-type.

*Italics* States Parties to the NPT that have not yet brought into force comprehensive safeguards agreements (CSAs) pursuant to Article III of the NPT.

\* Voluntary offer safeguards agreement with NPT nuclear-weapon States.

X 'X' in the 'small quantities protocols' column indicates that the State has an operative small quantities protocol (SQP). 'Amended' or 'In force' indicates that the operative SQP is based on the revised SQP standardized text.

*NB:* This table does not aim at listing all safeguards agreements that the Agency has concluded. Not included are agreements under which the application of safeguards has been suspended upon the entry into force of a CSA. Unless otherwise indicated, the safeguards agreements referred to are CSAs concluded pursuant to the NPT.

<sup>a</sup> An entry in this column does not imply the expression of any opinion whatsoever on the part of the Agency concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

<sup>b</sup> Provided that they meet certain eligibility criteria (including that the quantities of nuclear material do not exceed the limits set out in paragraph 37 of INFCIRC/153 (Corrected)), countries have the option to conclude an SQP to their CSAs that holds in abeyance the implementation of most of the detailed provisions set out in Part II of the CSAs as long as eligibility criteria continue to apply. This column contains countries whose CSA with an SQP based on the original standard text has been approved by the Board of Governors and for which, as far as the Secretariat is aware, these eligibility criteria continue to apply. For those States that have accepted the revised standard SQP text (approved by the Board of Governors on 20 September 2005) the current status is reflected.

<sup>c</sup> The Agency also applies safeguards for Taiwan, China, under two agreements, which entered into force on 13 October 1969 (reproduced in INFCIRC/133) and 6 December 1971 (reproduced in INFCIRC/158), respectively.

<sup>1</sup> *Sui generis* comprehensive safeguards agreement. On 28 November 2002, upon approval by the Board of Governors, an exchange of letters entered into force confirming that the safeguards agreement satisfies the requirement of Article III of the NPT.

<sup>2</sup> Safeguards agreement is pursuant to both the Treaty of Tlatelolco and the NPT.

<sup>3</sup> Date refers to the safeguards agreement concluded between Argentina, Brazil, ABACC and the Agency. On 18 March 1997, upon approval by the Board of Governors, an exchange of letters entered into force between Argentina and the Agency confirming that the safeguards agreement satisfies the requirements of Article 13 of the Treaty of Tlatelolco and Article III of the NPT to conclude a safeguards agreement with the Agency.

<sup>4</sup> The application of safeguards for Austria under the NPT bilateral safeguards agreement (reproduced in INFCIRC/156), in force since 23 July 1972, was suspended on 31 July 1996, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193), to which Austria had acceded, entered into force for Austria.

<sup>5</sup> Date refers to a safeguards agreement pursuant to Article III of the NPT. Upon approval by the Board of Governors, an exchange of letters entered into force (for Saint Lucia on 12 June 1996 and for Belize, Dominica, Saint Kitts and Nevis and Saint Vincent and the Grenadines on 18 March 1997) confirming that the safeguards agreement satisfies the requirement of Article 13 of the Treaty of Tlatelolco.

<sup>6</sup> Date refers to the safeguards agreement concluded between Argentina, Brazil, ABACC and the Agency. On 10 June 1997, upon approval by the Board of Governors, an exchange of letters entered into force between Brazil and the Agency confirming that the safeguards agreement satisfies the requirement of Article 13 of the Treaty of Tlatelolco. On 20 September 1999, upon approval by the Board of Governors, an exchange of letters entered into force confirming that the safeguards agreement also satisfies the requirement of Article III of the NPT.

<sup>7</sup> The application of safeguards for Bulgaria under the NPT bilateral safeguards agreement (reproduced in INFCIRC/178), in force since



- 29 February 1972, was suspended on 1 May 2009, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193), to which Bulgaria had acceded, entered into force for Bulgaria.
- <sup>8</sup> Date refers to a safeguards agreement pursuant to Article 13 of the Treaty of Tlatelolco. Upon approval by the Board of Governors, an exchange of letters entered into force (for Chile on 9 September 1996; for Colombia on 13 June 2001; for Panama on 20 November 2003) confirming that the safeguards agreement satisfies the requirement of Article III of the NPT.
- <sup>9</sup> The application of safeguards for Croatia under the NPT bilateral safeguards agreement (reproduced in INFCIRC/463), in force since 19 January 1995, was suspended on 1 April 2017, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193), to which Croatia had acceded, entered into force for Croatia.
- <sup>10</sup> The application of safeguards for Cyprus under the NPT bilateral safeguards agreement (reproduced in INFCIRC/189), in force since 26 January 1973, was suspended on 1 May 2008, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193), to which Cyprus had acceded, entered into force for Cyprus.
- <sup>11</sup> The application of safeguards for the Czech Republic under the NPT bilateral safeguards agreement (reproduced in INFCIRC/541), in force since 11 September 1997, was suspended on 1 October 2009, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193), to which the Czech Republic had acceded, entered into force for the Czech Republic.
- <sup>12</sup> The application of safeguards for Denmark under the NPT bilateral safeguards agreement (reproduced in INFCIRC/176), in force since 1 March 1972, was suspended on 21 February 1977, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193) entered into force for Denmark. Since 21 February 1977, INFCIRC/193 also applies to the Faroe Islands. Upon Greenland's secession from Euratom as of 31 January 1985, INFCIRC/176 re-entered into force for Greenland. The Additional Protocol for Greenland entered into force on 22 March 2013 (reproduced in INFCIRC/176/Add.1).
- <sup>13</sup> The application of safeguards for Estonia under the NPT bilateral safeguards agreement (reproduced in INFCIRC/547), in force since 24 November 1997, was suspended on 1 December 2005, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193), to which Estonia had acceded, entered into force for Estonia.
- <sup>14</sup> The application of safeguards for Finland under the NPT bilateral safeguards agreement (reproduced in INFCIRC/155), in force since 9 February 1972, was suspended on 1 October 1995, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193), to which Finland had acceded, entered into force for Finland.
- <sup>15</sup> The safeguards agreement is in connection with Additional Protocol I to the Treaty of Tlatelolco.
- <sup>16</sup> The NPT safeguards agreement of 7 March 1972 concluded with the German Democratic Republic (reproduced in INFCIRC/181) is no longer in force with effect from 3 October 1990, on which date the German Democratic Republic acceded to the Federal Republic of Germany.
- <sup>17</sup> The application of safeguards for Greece under the NPT bilateral safeguards agreement (reproduced in INFCIRC/166), in force since 1 March 1972, was suspended on 17 December 1981, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193), to which Greece had acceded, entered into force for Greece.
- <sup>18</sup> The application of safeguards for Hungary under the NPT bilateral safeguards agreement (reproduced in INFCIRC/174), in force since 30 March 1972, was suspended on 1 July 2007, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193), to which Hungary had acceded, entered into force for Hungary.
- <sup>19</sup> The application of safeguards for India under the safeguards agreement between the Agency, Canada and India (reproduced in INFCIRC/211), in force since 30 September 1971, was suspended as of 20 March 2015. The application of safeguards for India under the safeguards agreements between the Agency and India reproduced in the following INFCIRCs was suspended as of 30 June 2016: INFCIRC/260, in force since 17 November 1977; INFCIRC/360, in force since 27 September 1988; INFCIRC/374, in force since 11 October 1989; and INFCIRC/433, in force since 1 March 1994. Items subject to safeguards under the aforementioned safeguards agreements are subject to safeguards under the safeguards agreement between India and the Agency (reproduced in INFCIRC/754), which entered into force on 11 May 2009.
- <sup>20</sup> On 16 January 2016, as notified in its letter to the Director General of 7 January 2016, Iran began to provisionally apply its additional protocol in accordance with Article 17(b) of the additional protocol, pending its entry into force. The additional protocol, which was provisionally applied by Iran as of 16 January 2016, has not been applied since 23 February 2021.
- <sup>21</sup> The application of safeguards for Latvia under the NPT bilateral safeguards agreement (reproduced in INFCIRC/434), in force since 21 December 1993, was suspended on 1 October 2008, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193), to which Latvia had acceded, entered into force for Latvia.
- <sup>22</sup> The application of safeguards for Lithuania under the NPT bilateral safeguards agreement (reproduced in INFCIRC/413), in force since 15 October 1992, was suspended on 1 January 2008, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193), to which Lithuania had acceded, entered into force for Lithuania.
- <sup>23</sup> The application of safeguards for Malta under the NPT bilateral safeguards agreement (reproduced in INFCIRC/387), in force since 13 November 1990, was suspended on 1 July 2007, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193), to which Malta had acceded, entered into force for Malta.
- <sup>24</sup> The safeguards agreement was concluded pursuant to both the Treaty of Tlatelolco and the NPT. The application of safeguards under an earlier safeguards agreement pursuant to the Treaty of Tlatelolco, which entered into force on 6 September 1968 (reproduced in INFCIRC/118), was suspended as of 14 September 1973.
- <sup>25</sup> Whereas the NPT safeguards agreement and SQP with New Zealand (reproduced in INFCIRC/185) also apply to Cook Islands and Niue, the additional protocol thereto (reproduced in INFCIRC/185/Add.1) does not apply to those territories. Amendments to the SQP entered into force only for New Zealand on 24 February 2014 (reproduced in INFCIRC/185/Mod.1).
- <sup>26</sup> The application of safeguards for Poland under the NPT bilateral safeguards agreement (reproduced in INFCIRC/179), in force since

- 11 October 1972, was suspended on 1 March 2007, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193), to which Poland had acceded, entered into force for Poland.
- <sup>27</sup> The application of safeguards for Portugal under the NPT bilateral safeguards agreement (reproduced in INFCIRC/272), in force since 14 June 1979, was suspended on 1 July 1986, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193), to which Portugal had acceded, entered into force for Portugal.
- <sup>28</sup> The application of safeguards for Romania under the NPT bilateral safeguards agreement (reproduced in INFCIRC/180), in force since 27 October 1972, was suspended on 1 May 2010, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193), to which Romania had acceded, entered into force for Romania.
- <sup>29</sup> The NPT safeguards agreement concluded with the Socialist Federal Republic of Yugoslavia (reproduced in INFCIRC/204), which entered into force on 28 December 1973, continues to be applied for Serbia to the extent relevant to the territory of Serbia.
- <sup>30</sup> The application of safeguards for Slovakia under the NPT bilateral safeguards agreement with the Czechoslovak Socialist Republic (reproduced in INFCIRC/173), in force since 3 March 1972, was suspended on 1 December 2005, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193), to which Slovakia had acceded, entered into force for Slovakia.
- <sup>31</sup> The application of safeguards for Slovenia under the NPT bilateral safeguards agreement (reproduced in INFCIRC/538), in force since 1 August 1997, was suspended on 1 September 2006, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193), to which Slovenia had acceded, entered into force for Slovenia.
- <sup>32</sup> The designation employed does not imply the expression of any opinion whatsoever concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.
- <sup>33</sup> The application of safeguards for Sweden under the NPT bilateral safeguards agreement (reproduced in INFCIRC/234), in force since 14 April 1975, was suspended on 1 June 1995, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (reproduced in INFCIRC/193), to which Sweden had acceded, entered into force for Sweden.
- <sup>34</sup> Date refers to the INFCIRC/66-type safeguards agreement, concluded between the United Kingdom and the Agency, which remains in force.
- <sup>35</sup> The voluntary offer safeguards agreement between the United Kingdom and the Agency (reproduced in INFCIRC/951) and the additional protocol thereto (reproduced in INFCIRC/951/Add.1) entered into force on 31 December 2020 at 23:00 GMT.

**Table A7. Participation in multilateral treaties for which the Director General is the depositary (status as of 31 December 2022)**

|   | State/Organization <sup>a</sup> | P&I | ENC | AC | CNS | JC | CPPNM | A/CPNPM | VC | PVC | CSC | JP |
|---|---------------------------------|-----|-----|----|-----|----|-------|---------|----|-----|-----|----|
| * | Afghanistan                     |     |     |    |     |    | X     |         |    |     |     |    |
| * | Albania                         | X   | X   | X  | X   | X  | X     | X       |    |     |     |    |
| * | Algeria                         |     | X   | X  |     |    | X     | X       |    |     |     |    |
|   | Andorra                         |     |     |    |     |    | X     |         |    |     |     |    |
| * | Angola                          |     | X   |    | X   |    | X     | X       |    |     |     |    |
| * | Antigua and Barbuda             |     |     |    |     |    | X     | X       |    |     |     |    |
| * | Argentina                       | X   | X   | X  | X   | X  | X     | X       | X  | X   | X   |    |
| * | Armenia                         |     | X   | X  | X   | X  | X     | X       | X  |     |     |    |
| * | Australia                       | X   | X   | X  | X   | X  | X     | X       |    |     |     |    |
| * | Austria                         |     | X   | X  | X   | X  | X     | X       |    |     |     |    |
| * | Azerbaijan                      |     |     |    |     |    | X     | X       |    |     |     |    |
| * | Bahamas                         |     |     |    |     |    | X     |         |    |     |     |    |
| * | Bahrain                         |     | X   |    | X   |    | X     | X       |    |     |     |    |
| * | Bangladesh                      |     | X   | X  | X   |    | X     | X       |    |     |     |    |
| * | Barbados                        |     |     |    |     |    |       |         |    |     |     |    |
| * | Belarus                         | X   | X   | X  | X   | X  | X     |         | X  | X   |     |    |
| * | Belgium                         | X   | X   | X  | X   | X  | X     | X       |    |     |     |    |
| * | Belize                          |     |     |    |     |    |       |         |    |     |     |    |
| * | Benin                           | X   | X   | X  | X   | X  | X     | X       | X  | X   | X   | X  |
|   | Bhutan                          |     |     |    |     |    |       |         |    |     |     |    |
| * | Bolivia, Plurinational State of | X   | X   | X  | X   | X  | X     | X       | X  |     |     |    |
| * | Bosnia and Herzegovina          | X   | X   | X  | X   | X  | X     | X       | X  | X   |     |    |
| * | Botswana                        |     | X   | X  |     | X  | X     | X       |    |     |     |    |
| * | Brazil                          | X   | X   | X  | X   | X  | X     | X       | X  |     |     |    |
| * | Brunei Darussalam               | X   |     |    |     |    |       |         |    |     |     |    |
| * | Bulgaria                        | X   | X   | X  | X   | X  | X     | X       | X  |     |     | X  |

|   | State/Organization <sup>a</sup> | P&I | ENC | AC | CNS | JC | CPPNM | A/CPNM | VC | PVC | CSC | JP |
|---|---------------------------------|-----|-----|----|-----|----|-------|--------|----|-----|-----|----|
| * | Burkina Faso                    |     | X   | X  |     |    | X     | X      |    |     |     |    |
| * | Burundi                         |     |     |    |     |    |       |        |    |     |     |    |
|   | Cabo Verde                      |     |     |    |     |    | X     |        |    |     |     |    |
| * | Cambodia                        |     | X   | X  | X   |    | X     |        |    |     |     |    |
| * | Cameroon                        | X   | X   | X  |     |    | X     | X      | X  |     |     | X  |
| * | Canada                          | X   | X   | X  | X   | X  | X     | X      |    |     | X   |    |
| * | Central African Republic        |     |     |    |     |    | X     |        |    |     |     |    |
| * | Chad                            |     |     |    |     |    | X     | X      |    |     |     |    |
| * | Chile                           | X   | X   | X  | X   | X  | X     | X      | X  |     |     | X  |
| * | China                           | X   | X   | X  | X   | X  | X     | X      |    |     |     |    |
| * | Colombia                        | X   | X   | X  |     |    | X     | X      |    |     |     |    |
| * | Comoros                         |     |     |    |     |    | X     | X      |    |     |     |    |
| * | Congo                           | X   | X   |    | X   | X  | X     |        |    |     |     |    |
| * | Costa Rica                      |     | X   | X  |     |    | X     | X      |    |     |     |    |
| * | Côte d'Ivoire                   | X   | X   | X  |     |    | X     | X      |    |     |     |    |
| * | Croatia                         | X   | X   | X  | X   | X  | X     | X      | X  |     |     | X  |
| * | Cuba                            | X   | X   | X  | X   | X  | X     | X      | X  |     |     |    |
| * | Cyprus                          | X   | X   | X  | X   | X  | X     | X      |    |     |     |    |
| * | Czech Republic                  | X   | X   | X  | X   | X  | X     | X      | X  |     |     | X  |
|   | Dem. People's Rep. of Korea     |     |     |    |     |    |       |        |    |     |     |    |
| * | Dem. Rep. of the Congo          | X   |     |    |     |    | X     |        |    |     |     |    |
| * | Denmark                         | X   | X   | X  | X   | X  | X     | X      |    |     |     | X  |
| * | Djibouti                        |     |     |    |     |    | X     | X      |    |     |     |    |
| * | Dominica                        |     |     |    |     |    | X     |        |    |     |     |    |
| * | Dominican Republic              |     | X   |    |     |    | X     | X      |    |     |     |    |
| * | Ecuador                         | X   | X   | X  |     |    | X     | X      |    |     |     |    |
| * | Egypt                           | X   | X   | X  |     |    |       |        | X  |     |     | X  |
| * | El Salvador                     |     | X   | X  |     |    | X     | X      |    |     |     |    |

|   | State/Organization <sup>a</sup> | P&I | ENC | AC | CNS | JC | CPPNM | A/CPNM | VC | PVC | CSC | JP |
|---|---------------------------------|-----|-----|----|-----|----|-------|--------|----|-----|-----|----|
|   | Equatorial Guinea               |     |     |    |     |    | X     |        |    |     |     |    |
| * | Eritrea                         | X   | X   | X  |     | X  | X     | X      |    |     |     |    |
| * | Estonia                         | X   | X   | X  | X   | X  | X     | X      | X  |     |     | X  |
| * | Eswatini                        |     |     |    |     |    | X     | X      |    |     |     |    |
| * | Ethiopia                        |     |     |    |     |    |       |        |    |     |     |    |
| * | Fiji                            |     |     |    |     |    | X     | X      |    |     |     |    |
| * | Finland                         | X   | X   | X  | X   | X  | X     | X      |    |     |     | X  |
| * | France                          |     | X   | X  | X   | X  | X     | X      |    |     |     | X  |
| * | Gabon                           |     | X   | X  |     | X  | X     | X      |    |     |     |    |
|   | Gambia                          |     |     |    |     |    |       |        |    |     |     |    |
| * | Georgia                         | X   | X   | X  |     | X  | X     | X      |    |     |     |    |
| * | Germany                         | X   | X   | X  | X   | X  | X     | X      |    |     |     | X  |
| * | Ghana                           | X   | X   | X  | X   | X  | X     | X      | X  | X   | X   | X  |
| * | Greece                          | X   | X   | X  | X   | X  | X     | X      |    |     |     | X  |
| * | Grenada                         |     |     |    |     |    | X     |        |    |     |     |    |
| * | Guatemala                       |     | X   | X  |     |    | X     |        |    |     |     |    |
|   | Guinea                          |     |     |    |     |    | X     |        |    |     |     |    |
|   | Guinea-Bissau                   |     |     |    |     |    | X     |        |    |     |     |    |
| * | Guyana                          |     |     |    |     |    | X     |        |    |     |     |    |
| * | Haiti                           |     |     |    |     |    |       |        |    |     |     |    |
| * | Holy See                        | X   |     |    |     |    |       |        |    |     |     |    |
| * | Honduras                        |     |     |    |     |    | X     |        |    |     |     |    |
| * | Hungary                         | X   | X   | X  | X   | X  | X     | X      | X  |     |     | X  |
| * | Iceland                         | X   | X   | X  | X   | X  | X     | X      |    |     |     |    |
| * | India                           | X   | X   | X  | X   |    | X     | X      |    |     | X   |    |
| * | Indonesia                       | X   | X   | X  | X   | X  | X     | X      |    |     |     |    |
| * | Iran, Islamic Republic of       | X   | X   | X  |     |    |       |        |    |     |     |    |
| * | Iraq                            | X   | X   | X  |     |    | X     |        |    |     |     |    |

|   | State/Organization <sup>a</sup> | P&I | ENC | AC | CNS | JC | CPPNM | A/CPNM | VC | PVC | CSC | JP |
|---|---------------------------------|-----|-----|----|-----|----|-------|--------|----|-----|-----|----|
| * | Ireland                         | X   | X   | X  | X   | X  | X     | X      |    |     |     |    |
| * | Israel                          |     | X   | X  |     |    | X     | X      |    |     |     |    |
| * | Italy                           | X   | X   | X  | X   | X  | X     | X      |    |     |     | X  |
| * | Jamaica                         | X   |     |    |     |    | X     | X      |    |     |     |    |
| * | Japan                           | X   | X   | X  | X   | X  | X     | X      |    |     | X   |    |
| * | Jordan                          | X   | X   | X  | X   | X  | X     | X      | X  | X   |     |    |
| * | Kazakhstan                      | X   | X   | X  | X   | X  | X     | X      | X  | X   |     |    |
| * | Kenya                           |     |     |    |     |    | X     | X      |    |     |     |    |
|   | Kiribati                        |     |     |    |     |    |       |        |    |     |     |    |
| * | Korea, Republic of              | X   | X   | X  | X   | X  | X     | X      |    |     |     |    |
| * | Kuwait                          | X   | X   | X  | X   |    | X     | X      |    |     |     |    |
| * | Kyrgyzstan                      |     |     |    |     | X  | X     | X      |    |     |     |    |
| * | Lao People's Dem. Rep.          |     | X   | X  |     |    | X     |        |    |     |     |    |
| * | Latvia                          | X   | X   | X  | X   | X  | X     | X      | X  | X   |     | X  |
| * | Lebanon                         | X   | X   | X  | X   |    | X     |        | X  |     |     |    |
| * | Lesotho                         | X   | X   | X  |     | X  | X     | X      |    |     |     |    |
| * | Liberia                         |     |     |    |     |    |       |        |    |     |     |    |
| * | Libya                           |     | X   | X  | X   |    | X     | X      |    |     |     |    |
| * | Liechtenstein                   |     | X   | X  |     |    | X     | X      |    |     |     |    |
| * | Lithuania                       | X   | X   | X  | X   | X  | X     | X      | X  |     |     | X  |
| * | Luxembourg                      | X   | X   | X  | X   | X  | X     | X      |    |     |     |    |
| * | Madagascar                      |     | X   | X  | X   | X  | X     | X      |    |     |     |    |
| * | Malawi                          |     | X   | X  |     | X  | X     | X      |    |     |     |    |
| * | Malaysia                        |     | X   | X  |     |    |       |        |    |     |     |    |
|   | Maldives                        |     |     |    |     |    |       |        |    |     |     |    |
| * | Mali                            |     | X   | X  | X   |    | X     | X      |    |     |     |    |
| * | Malta                           |     |     |    | X   | X  | X     | X      |    |     |     |    |
| * | Marshall Islands                |     |     |    |     |    | X     | X      |    |     |     |    |

|   | State/Organization <sup>a</sup> | P&I | ENC | AC | CNS | JC | CPPNM | A/CPPNM | VC | PVC | CSC | JP |
|---|---------------------------------|-----|-----|----|-----|----|-------|---------|----|-----|-----|----|
| * | Mauritania                      |     | X   | X  |     | X  | X     | X       |    |     |     |    |
| * | Mauritius                       | X   | X   | X  |     | X  |       |         | X  |     |     |    |
| * | Mexico                          | X   | X   | X  | X   | X  | X     | X       | X  |     |     |    |
|   | Micronesia, Federated States of |     |     |    |     |    |       |         |    |     |     |    |
| * | Monaco                          |     | X   | X  |     |    | X     | X       |    |     |     |    |
| * | Mongolia                        | X   | X   | X  |     |    | X     |         |    |     |     |    |
| * | Montenegro                      | X   | X   | X  | X   | X  | X     | X       | X  | X   | X   | X  |
| * | Morocco                         | X   | X   | X  | X   | X  | X     | X       | X  | X   | X   | X  |
| * | Mozambique                      | X   | X   | X  |     |    | X     | X       |    |     |     |    |
| * | Myanmar                         |     | X   | X  | X   |    | X     | X       |    |     |     |    |
| * | Namibia                         |     | X   | X  |     |    | X     | X       |    |     |     |    |
|   | Nauru                           |     |     |    |     |    | X     | X       |    |     |     |    |
| * | Nepal                           |     |     |    |     |    |       |         |    |     |     |    |
| * | Netherlands                     | X   | X   | X  | X   | X  | X     | X       |    |     |     | X  |
| * | New Zealand                     | X   | X   | X  |     |    | X     | X       |    |     |     |    |
| * | Nicaragua                       | X   | X   | X  |     |    | X     | X       |    |     |     |    |
| * | Niger                           | X   | X   | X  | X   | X  | X     | X       | X  | X   |     |    |
| * | Nigeria                         | X   | X   | X  | X   | X  | X     | X       | X  |     |     |    |
|   | Niue                            |     |     |    |     |    | X     |         |    |     |     |    |
| * | North Macedonia                 |     | X   | X  | X   | X  | X     | X       | X  |     |     |    |
| * | Norway                          | X   | X   | X  | X   | X  | X     | X       |    |     |     | X  |
| * | Oman                            | X   | X   | X  | X   | X  | X     | X       |    |     |     |    |
| * | Pakistan                        | X   | X   | X  | X   |    | X     | X       |    |     |     |    |
| * | Palau                           | X   |     |    |     |    | X     |         |    |     |     |    |
|   | Palestine                       |     |     |    |     |    | Xb    | Xb      |    |     |     |    |
| * | Panama                          |     | X   | X  |     |    | X     | X       |    |     |     |    |
| * | Papua New Guinea                |     |     |    |     |    |       |         |    |     |     |    |
| * | Paraguay                        | X   | X   | X  | X   | X  | X     | X       |    |     |     |    |

|   | State/Organization <sup>a</sup>  | P&I | ENC | AC | CNS | JC | CPPNM | A/CPNM | VC | PVC | CSC | JP |
|---|----------------------------------|-----|-----|----|-----|----|-------|--------|----|-----|-----|----|
| * | Peru                             |     | X   | X  | X   | X  | X     | X      | X  |     |     |    |
| * | Philippines                      | X   | X   | X  |     |    | X     | X      | X  |     |     |    |
| * | Poland                           | X   | X   | X  | X   | X  | X     | X      | X  | X   |     | X  |
| * | Portugal                         | X   | X   | X  | X   | X  | X     | X      |    |     |     |    |
| * | Qatar                            |     | X   | X  | X   |    | X     | X      |    |     |     |    |
| * | Republic of Moldova              | X   | X   | X  | X   | X  | X     | X      | X  |     |     |    |
| * | Romania                          | X   | X   | X  | X   | X  | X     | X      | X  | X   | X   | X  |
| * | Russian Federation               | X   | X   | X  | X   | X  | X     | X      | X  |     |     |    |
| * | Rwanda                           |     | X   | X  |     | X  | X     | X      | X  |     |     |    |
| * | Saint Kitts and Nevis            |     |     |    |     |    | X     | X      |    |     |     |    |
| * | Saint Lucia                      |     |     |    |     |    | X     | X      |    |     |     |    |
| * | Saint Vincent and the Grenadines |     | X   | X  |     |    |       |        | X  |     |     | X  |
| * | Samoa                            |     |     |    |     |    |       |        |    |     |     |    |
| * | San Marino                       |     |     |    |     |    | X     | X      |    |     |     |    |
|   | São Tomé and Príncipe            |     |     |    |     |    |       |        |    |     |     |    |
| * | Saudi Arabia                     |     | X   | X  | X   | X  | X     | X      | X  | X   |     |    |
| * | Senegal                          | X   | X   | X  | X   | X  | X     | X      | X  |     |     |    |
| * | Serbia                           | X   | X   | X  | X   | X  | X     | X      | X  |     |     |    |
| * | Seychelles                       |     |     |    |     |    | X     | X      |    |     |     |    |
| * | Sierra Leone                     |     |     |    |     |    |       |        |    |     |     |    |
| * | Singapore                        | X   | X   | X  | X   |    | X     | X      |    |     |     |    |
| * | Slovakia                         | X   | X   | X  | X   | X  | X     | X      | X  |     |     | X  |
| * | Slovenia                         | X   | X   | X  | X   | X  | X     | X      |    |     |     | X  |
|   | Solomon Islands                  |     |     |    |     |    |       |        |    |     |     |    |
|   | Somalia                          |     |     |    |     |    |       |        |    |     |     |    |
| * | South Africa                     | X   | X   | X  | X   | X  | X     |        |    |     |     |    |
|   | South Sudan                      |     |     |    |     |    |       |        |    |     |     |    |
| * | Spain                            | X   | X   | X  | X   | X  | X     | X      |    |     |     |    |



|   | State/Organization <sup>a</sup>   | P&I | ENC | AC | CNS | JC | CPPNM | A/CPNM | VC | PVC | CSC | JP |
|---|-----------------------------------|-----|-----|----|-----|----|-------|--------|----|-----|-----|----|
| * | Sri Lanka                         |     | X   | X  | X   |    |       |        |    |     |     |    |
| * | Sudan                             |     |     |    |     |    | X     |        |    |     |     |    |
|   | Suriname                          |     |     |    |     |    |       |        |    |     |     |    |
| * | Sweden                            | X   | X   | X  | X   | X  | X     | X      |    |     |     | X  |
| * | Switzerland                       | X   | X   | X  | X   | X  | X     | X      |    |     |     | X  |
| * | Syrian Arab Republic              | X   | X   | X  | X   | X  | X     | X      |    |     |     |    |
| * | Tajikistan                        | X   | X   | X  |     | X  | X     | X      |    |     |     |    |
| * | Thailand                          | X   | X   | X  | X   | X  | X     | X      |    |     |     |    |
|   | Timor Leste                       |     |     |    |     |    |       |        |    |     |     |    |
| * | Togo                              |     |     |    |     |    | X     |        |    |     |     |    |
| * | Tonga                             |     |     |    |     |    | X     |        |    |     |     |    |
| * | Trinidad and Tobago               |     |     |    |     |    | X     |        | X  |     |     |    |
| * | Tunisia                           | X   | X   | X  | X   |    | X     | X      |    |     |     |    |
| * | Türkiye                           | X   | X   | X  | X   |    | X     | X      |    |     |     | X  |
| * | Turkmenistan                      |     |     |    |     |    | X     | X      |    |     |     |    |
|   | Tuvalu                            |     |     |    |     |    |       |        |    |     |     |    |
| * | Uganda                            |     |     |    |     |    | X     |        |    |     |     |    |
| * | Ukraine                           | X   | X   | X  | X   | X  | X     | X      | X  |     |     | X  |
| * | United Arab Emirates              |     | X   | X  | X   | X  | X     | X      |    | X   | X   | X  |
| * | United Kingdom                    | X   | X   | X  | X   | X  | X     | X      |    |     |     |    |
| * | United Republic of Tanzania       |     | X   | X  |     |    | X     |        |    |     |     |    |
| * | United States of America          |     | X   | X  | X   | X  | X     | X      |    |     | X   |    |
| * | Uruguay                           |     | X   | X  | X   | X  | X     | X      | X  |     |     | X  |
| * | Uzbekistan                        |     |     |    |     | X  | X     | X      |    |     |     |    |
| * | Vanuatu                           |     |     |    |     |    |       |        |    |     |     |    |
| * | Venezuela, Bolivarian Republic of |     | X   |    |     |    |       |        |    |     |     |    |
| * | Viet Nam                          | X   | X   | X  | X   | X  | X     | X      |    |     |     |    |
| * | Yemen                             |     |     |    |     |    | X     |        |    |     |     |    |

|   | State/Organization <sup>a</sup> | P&I | ENC | AC | CNS | JC | CPPNM | A/CPPNM | VC | PVC | CSC | JP |
|---|---------------------------------|-----|-----|----|-----|----|-------|---------|----|-----|-----|----|
| * | Zambia                          |     |     |    |     |    | X     |         |    |     |     |    |
| * | Zimbabwe                        |     | X   | X  |     | X  | X     |         |    |     |     |    |
|   | Euratom                         |     | X   | X  | X   | X  | X     | X       |    |     |     |    |
|   | FAO                             |     | X   | X  |     |    |       |         |    |     |     |    |
|   | WHO                             |     | X   | X  |     |    |       |         |    |     |     |    |
|   | WMO                             |     | X   | X  |     |    |       |         |    |     |     |    |

|         |                                                                                                           |
|---------|-----------------------------------------------------------------------------------------------------------|
| P&I     | Agreement on the Privileges and Immunities of the IAEA                                                    |
| ENC     | Convention on Early Notification of a Nuclear Accident                                                    |
| AC      | Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency                      |
| CNS     | Convention on Nuclear Safety                                                                              |
| JC      | Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management |
| CPPNM   | Convention on the Physical Protection of Nuclear Material                                                 |
| A/CPPNM | Amendment to the Convention on the Physical Protection of Nuclear Material                                |
| VC      | Vienna Convention on Civil Liability for Nuclear Damage                                                   |
| PVC     | Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage                             |
| CSC     | Convention on Supplementary Compensation for Nuclear Damage                                               |
| JP      | Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention              |
| *       | Agency Member State                                                                                       |
| X       | Party                                                                                                     |

<sup>a</sup> An entry in this column does not imply the expression of any opinion whatsoever on the part of the Agency concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

<sup>b</sup> Acceded as State of Palestine.

**Table A8. Member States that have concluded a Revised Supplementary Agreement (RSA) concerning the Provision of Technical Assistance by the Agency (status as of 31 December 2022)<sup>a</sup>**

|                                  |                                  |                                   |
|----------------------------------|----------------------------------|-----------------------------------|
| Afghanistan                      | Gabon                            | North Macedonia                   |
| Albania                          | Georgia                          | Oman                              |
| Algeria                          | Ghana                            | Pakistan                          |
| Angola                           | Greece                           | Palau                             |
| Antigua and Barbuda              | Guatemala                        | Panama                            |
| Argentina                        | Guyana                           | Paraguay                          |
| Armenia                          | Haiti                            | Peru                              |
| Azerbaijan                       | Honduras                         | Philippines                       |
| Bahrain                          | Hungary                          | Poland                            |
| Bangladesh                       | Iceland                          | Portugal                          |
| Belarus                          | Indonesia                        | Qatar                             |
| Belize                           | Iran, Islamic Republic of        | Republic of Moldova               |
| Benin                            | Iraq                             | Romania                           |
| Bolivia, Plurinational State of  | Ireland                          | Rwanda                            |
| Bosnia and Herzegovina           | Israel                           | Saint Lucia                       |
| Botswana                         | Jamaica                          | Saint Vincent and the Grenadines  |
| Brazil                           | Jordan                           | Saudi Arabia                      |
| Brunei Darussalam                | Kazakhstan                       | Senegal                           |
| Bulgaria                         | Kenya                            | Serbia                            |
| Burkina Faso                     | Korea, Republic of               | Seychelles                        |
| Burundi                          | Kuwait                           | Sierra Leone                      |
| Cambodia                         | Kyrgyzstan                       | Singapore                         |
| Cameroon                         | Lao People's Democratic Republic | Slovakia                          |
| Central African Republic         | Latvia                           | Slovenia                          |
| Chad                             | Lebanon                          | South Africa                      |
| Chile                            | Lesotho                          | Spain                             |
| China                            | Liberia                          | Sri Lanka                         |
| Colombia                         | Libya                            | Sudan                             |
| Comoros                          | Lithuania                        | Syrian Arab Republic              |
| Congo                            | Madagascar                       | Tajikistan                        |
| Costa Rica                       | Malawi                           | Thailand                          |
| Côte d'Ivoire                    | Malaysia                         | Togo                              |
| Croatia                          | Mali                             | Trinidad and Tobago               |
| Cuba                             | Malta                            | Tunisia                           |
| Cyprus                           | Marshall Islands                 | Türkiye                           |
| Czech Republic                   | Mauritania                       | Turkmenistan                      |
| Democratic Republic of the Congo | Mauritius                        | Uganda                            |
| Djibouti                         | Mexico                           | Ukraine                           |
| Dominica                         | Mongolia                         | United Arab Emirates              |
| Dominican Republic               | Montenegro                       | United Republic of Tanzania       |
| Ecuador                          | Morocco                          | Uruguay                           |
| Egypt                            | Mozambique                       | Uzbekistan                        |
| El Salvador                      | Myanmar                          | Vanuatu                           |
| Eritrea                          | Namibia                          | Venezuela, Bolivarian Republic of |
| Estonia                          | Nepal                            | Viet Nam                          |
| Eswatini                         | Nicaragua                        | Zambia                            |
| Ethiopia                         | Niger                            | Zimbabwe                          |
| Fiji                             | Nigeria                          |                                   |

<sup>a</sup> In 2022, Comoros concluded an RSA with the Agency. By the end of the year, there were 143 States party to an RSA.

**Table A9. Acceptance of Amendment to Article VI of the Agency's Statute (status as of 31 December 2022)<sup>a</sup>**

|                        |                    |                     |
|------------------------|--------------------|---------------------|
| Afghanistan            | Germany            | Netherlands         |
| Albania                | Greece             | Norway              |
| Algeria                | Holy See           | Pakistan            |
| Argentina              | Hungary            | Panama              |
| Austria                | Iceland            | Peru                |
| Belarus                | Ireland            | Poland              |
| Belgium                | Israel             | Portugal            |
| Bosnia and Herzegovina | Italy              | Republic of Moldova |
| Brazil                 | Japan              | Romania             |
| Bulgaria               | Kazakhstan         | San Marino          |
| Canada                 | Korea, Republic of | Slovakia            |
| Colombia               | Latvia             | Slovenia            |
| Croatia                | Libya              | South Africa        |
| Cyprus                 | Liechtenstein      | Spain               |
| Czech Republic         | Lithuania          | Sweden              |
| Denmark                | Luxembourg         | Switzerland         |
| El Salvador            | Malta              | Tunisia             |
| Estonia                | Mexico             | Türkiye             |
| Ethiopia               | Monaco             | Ukraine             |
| Finland                | Morocco            | United Kingdom      |
| France                 | Myanmar            | Uruguay             |

<sup>a</sup> In 2022, Belgium accepted the Amendment to Article VI of the Agency's Statute. By the end of the year, there were 63 States.

**Table A10. Acceptance of Amendment to Article XIV.A of the Agency's Statute (status as of 31 December 2022)<sup>a</sup>**

|                        |                           |                      |
|------------------------|---------------------------|----------------------|
| Albania                | Greece                    | Pakistan             |
| Algeria                | Holy See                  | Peru                 |
| Argentina              | Hungary                   | Poland               |
| Australia              | Iceland                   | Portugal             |
| Austria                | Iran, Islamic Republic of | Republic of Moldova  |
| Belarus                | Ireland                   | Romania              |
| Belgium                | Italy                     | San Marino           |
| Bosnia and Herzegovina | Japan                     | Seychelles           |
| Brazil                 | Kazakhstan                | Slovakia             |
| Bulgaria               | Kenya                     | Slovenia             |
| Canada                 | Korea, Republic of        | South Africa         |
| Colombia               | Latvia                    | Spain                |
| Croatia                | Liechtenstein             | Sweden               |
| Cyprus                 | Lithuania                 | Switzerland          |
| Czech Republic         | Luxembourg                | Syrian Arab Republic |
| Denmark                | Malta                     | Tunisia              |
| Ecuador                | Mexico                    | Türkiye              |
| Estonia                | Monaco                    | Ukraine              |
| Finland                | Myanmar                   | United Kingdom       |
| France                 | Netherlands               |                      |
| Germany                | Norway                    |                      |

<sup>a</sup> In 2022, Belgium accepted the Amendment to Article XIV.A of the Agency's Statute. By the end of the year, there were 61 States.

**Table A11. Multilateral treaties negotiated and adopted under the auspices of the Agency and/or for which the Director General is the depositary (status and relevant developments)**

*Agreement on the Privileges and Immunities of the IAEA* (reproduced in INFCIRC/9/Rev.2). In 2022, there was 1 new Party to the Agreement. By the end of the year, there were 92 Parties.

*Convention on Early Notification of a Nuclear Accident* (reproduced in INFCIRC/335). Entered into force on 27 October 1986. In 2022, there was 1 new Party to the Convention. By the end of the year, there were 132 Parties.

*Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency* (reproduced in INFCIRC/336). Entered into force on 26 February 1987. In 2022, there were 3 new Parties to the Convention. By the end of the year, there were 127 Parties.

*Convention on Nuclear Safety* (reproduced in INFCIRC/449). Entered into force on 24 October 1996. In 2022, the status of the Convention remained unchanged with 91 Parties.

*Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management* (reproduced in INFCIRC/546). Entered into force on 18 June 2001. In 2022, there were 2 new Parties to the Convention. By the end of the year, there were 88 Parties.

*Convention on the Physical Protection of Nuclear Material* (reproduced in INFCIRC/274/Rev.1). Entered into force on 8 February 1987. In 2022, the status of the Convention remained unchanged with 164 Parties.

*Amendment to the Convention on the Physical Protection of Nuclear Material*. Entered into force on 8 May 2016. In 2022, there were 4 new Parties to the Amendment. By the end of the year, there were 131 Parties.

*Vienna Convention on Civil Liability for Nuclear Damage* (reproduced in INFCIRC/500). Entered into force on 12 November 1977. In 2022, there was 1 new Party to the Convention. By the end of the year, there were 44 Parties.

*Optional Protocol Concerning the Compulsory Settlement of Disputes* (reproduced in INFCIRC/500/Add.3). Entered into force on 13 May 1999. In 2022, the status of the Protocol remained unchanged with 2 Parties.

*Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage* (reproduced in INFCIRC/566). Entered into force on 4 October 2003. In 2022, the status of the Protocol remained unchanged with 15 Parties.

*Convention on Supplementary Compensation for Nuclear Damage* (reproduced in INFCIRC/567). Entered into force on 15 April 2015. In 2022, the status of the Convention remained unchanged with 11 Parties.

*Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention* (reproduced in INFCIRC/402). Entered into force on 27 April 1992. In 2022, there were 2 new Parties to the Protocol. By the end of the year, there were 33 Parties.

*Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (RCA), 2017* (reproduced in INFCIRC/919). Entered into force on 11 June 2017. In 2022, the status of the Agreement remained unchanged with 19 Parties.

*African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA)* (reproduced in INFCIRC/935). Entered into force on 4 April 2020. In 2022, there were 10 new Parties to the Agreement. By the end of the year, there were 23 Parties.

*Agreement to further extend the Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL) (Second Extension)* (reproduced in INFCIRC/582/Add. 5). Entered into force on 5 September 2020. In 2022, there was 1 new Party to the Agreement. By the end of the year, there were 21 Parties.

*Co-operative Agreement for Arab States in Asia for Research, Development and Training Related to Nuclear Science and Technology (the 2017 ARASIA)* (reproduced in INFCIRC/929). Entered into force on 28 July 2020. In 2022, the status of the Agreement remained unchanged with 6 Parties.

*Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project* (reproduced in INFCIRC/702). Entered into force on 24 October 2007. In 2022, the status of the Agreement remained unchanged with 7 Parties.

*Agreement on the Privileges and Immunities of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project* (reproduced in INFCIRC/703). Entered into force on 24 October 2007. In 2022, the status of the Agreement remained unchanged with 6 Parties.

Table A12. Nuclear power status worldwide – 2022 <sup>a</sup>

| Country                   | Reactors in operation |             | Reactors under construction |             | Nuclear electricity supplied in 2022 |            | Total operating experience through 2022 |        |
|---------------------------|-----------------------|-------------|-----------------------------|-------------|--------------------------------------|------------|-----------------------------------------|--------|
|                           | No. of units          | Total MW(e) | No. of units                | Total MW(e) | TW·h                                 | % of total | Years                                   | Months |
| Argentina                 | 3                     | 1 641       | 1                           | 25          | 7.5                                  | 5.4        | 97                                      | 2      |
| Armenia                   | 1                     | 416         |                             |             | 2.6                                  | 31.0       | 55                                      | 3      |
| Bangladesh                |                       |             | 2                           | 2 160       |                                      |            |                                         |        |
| Belarus                   | 1                     | 1 110       | 1                           | 1 110       | 4.4                                  | 11.9       | 2                                       | 2      |
| Belgium                   | 6                     | 4 936       |                             |             | 41.7                                 | 46.4       | 324                                     | 4      |
| Brazil                    | 2                     | 1 884       | 1                           | 1 340       | 13.7                                 | 2.5        | 63                                      | 3      |
| Bulgaria                  | 2                     | 2 006       |                             |             | 15.8                                 | 32.5       | 173                                     | 3      |
| Canada                    | 19                    | 13 624      |                             |             | 81.7                                 | 12.9       | 903                                     | 0      |
| China                     | 54                    | 52 181      | 20                          | 20 284      | 395.4                                | 5.0        | 513                                     | 2      |
| Czech Republic            | 6                     | 3 934       |                             |             | 29.3                                 | 36.7       | 188                                     | 10     |
| Egypt                     |                       |             | 2                           | 2 200       |                                      |            |                                         |        |
| Finland                   | 5                     | 4 394       |                             |             | 24.2                                 | 35.0       | 176                                     | 2      |
| France                    | 56                    | 61 370      | 1                           | 1 630       | 282.1                                | 62.6       | 2 449                                   | 0      |
| Germany                   | 3                     | 4 055       |                             |             | 31.9                                 | 5.8        | 834                                     | 8      |
| Hungary                   | 4                     | 1 916       |                             |             | 15.0                                 | 47.0       | 150                                     | 2      |
| India                     | 19                    | 6 290       | 8                           | 6 028       | 42                                   | 3.1        | 594                                     | 11     |
| Iran, Islamic Republic of | 1                     | 915         | 1                           | 974         | 6.0                                  | 1.7        | 11                                      | 4      |
| Japan                     | 10                    | 9 486       | 2                           | 2 653       | 51.9                                 | 6.1        | 2 020                                   | 6      |
| Korea, Republic of        | 25                    | 24 489      | 3                           | 4 020       | 167.5                                | 30.4       | 644                                     | 9      |
| Mexico                    | 2                     | 1 552       |                             |             | 10.5                                 | 4.5        | 61                                      | 11     |
| Netherlands               | 1                     | 482         |                             |             | 3.9                                  | 3.3        | 78                                      | 0      |
| Pakistan                  | 6                     | 3 262       |                             |             | 22.2                                 | 16.2       | 98                                      | 9      |
| Romania                   | 2                     | 1 300       |                             |             | 10.2                                 | 19.3       | 41                                      | 11     |
| Russian Federation        | 37                    | 27 727      | 3                           | 2 700       | 209.5                                | 19.6       | 1 447                                   | 7      |
| Slovakia                  | 4                     | 1 868       | 2                           | 880         | 14.8                                 | 59.2       | 184                                     | 7      |

| Country                         | Reactors in operation  |                            | Reactors under construction |               | Nuclear electricity supplied in 2022 |            | Total operating experience through 2022 |           |
|---------------------------------|------------------------|----------------------------|-----------------------------|---------------|--------------------------------------|------------|-----------------------------------------|-----------|
|                                 | No. of units           | Total MW(e)                | No. of units                | Total MW(e)   | TW-h                                 | % of total | Years                                   | Months    |
| Slovenia                        | 1                      | 688                        |                             |               | 5.3                                  | 42.8       | 41                                      | 3         |
| South Africa                    | 2                      | 1 854                      |                             |               | 10.1                                 | 4.9        | 76                                      | 3         |
| Spain                           | 7                      | 7 123                      |                             |               | 56.2                                 | 20.3       | 368                                     | 2         |
| Sweden                          | 6                      | 6 937                      |                             |               | 50.0                                 | 29.5       | 486                                     | 0         |
| Switzerland                     | 4                      | 2 973                      |                             |               | 23.2                                 | 36.4       | 236                                     | 11        |
| Türkiye                         |                        |                            | 4                           | 4 456         |                                      |            |                                         |           |
| Ukraine <sup>b</sup>            | 15                     | 13 107                     | 2                           | 2 070         | NA                                   | NA         | 563                                     | 6         |
| United Arab Emirates            | 3                      | 4 011                      | 1                           | 1 310         | 19.3                                 | 6.8        | 4                                       | 0         |
| United Kingdom                  | 9                      | 5 883                      | 2                           | 3 260         | 43.6                                 | 14.2       | 1 658                                   | 9         |
| United States of America        | 92                     | 94 718                     | 2                           | 2 234         | 772.2                                | 18.2       | 4 825                                   | 9         |
| <b>Worldwide<sup>c, d</sup></b> | <b>438<sup>e</sup></b> | <b>393 823<sup>e</sup></b> | <b>58</b>                   | <b>59 334</b> | <b>2 486.6</b>                       | <b>NA</b>  | <b>19 764</b>                           | <b>11</b> |

**Note:** NA — Not available.

<sup>a</sup> Source: Agency's Power Reactor Information System (PRIS) ([www.iaea.org/pris](http://www.iaea.org/pris)) as per data provided by Member States by the end of May 2023.

<sup>b</sup> The total electricity production does not include Ukrainian reactor units as operational data were not submitted for the year 2022 by the time of publication.

<sup>c</sup> The total figures include the following data from Taiwan, China: 3 units, 2 859 MW(e) in operation and 22.9 TW-h of electricity supplied, accounting for 9.1% of the total electricity mix.

<sup>d</sup> The total operating experience also includes shutdown plants in Italy (80 years, 8 months), Kazakhstan (25 years, 10 months), and Lithuania (43 years, 6 months), and shutdown and operational plants in Taiwan, China (239 years, 8 months).

<sup>e</sup> The total figures include data for units where operation remained suspended: India (4 units; 639 MW(e)) and Japan (23 units, 22 193 MW(e)).



Table A13. Member State participation in selected Agency activities in 2022

| Member State                    | No. of research contracts and agreements | No. of Collaborating Centres | Services provided to Member States |                                   |                            |
|---------------------------------|------------------------------------------|------------------------------|------------------------------------|-----------------------------------|----------------------------|
|                                 |                                          |                              | ALMERA <sup>a</sup>                | Dosimetry audits for radiotherapy | Plant irradiation services |
| Afghanistan                     |                                          |                              |                                    |                                   |                            |
| Albania                         | 4                                        |                              |                                    |                                   |                            |
| Algeria                         | 12                                       |                              |                                    |                                   |                            |
| Angola                          | 1                                        |                              |                                    |                                   |                            |
| Antigua and Barbuda             |                                          |                              |                                    |                                   |                            |
| Argentina                       | 53                                       | 1                            | 2                                  |                                   |                            |
| Armenia                         | 1                                        |                              |                                    |                                   |                            |
| Australia                       | 38                                       | 1                            | 3                                  | 9                                 |                            |
| Austria                         | 8                                        | 1                            | 4                                  |                                   |                            |
| Azerbaijan                      | 5                                        |                              |                                    |                                   |                            |
| Bahamas                         | 1                                        |                              |                                    |                                   |                            |
| Bahrain                         |                                          |                              |                                    |                                   |                            |
| Bangladesh                      | 16                                       |                              |                                    | 11                                |                            |
| Barbados                        |                                          |                              |                                    |                                   |                            |
| Belarus                         | 6                                        |                              | 1                                  |                                   |                            |
| Belgium                         | 20                                       |                              | 2                                  | 1                                 |                            |
| Belize                          |                                          |                              |                                    |                                   |                            |
| Benin                           | 1                                        |                              |                                    |                                   |                            |
| Bolivia, Plurinational State of | 1                                        |                              |                                    |                                   |                            |
| Bosnia and Herzegovina          | 2                                        |                              | 3                                  | 5                                 | 2                          |
| Botswana                        | 1                                        |                              |                                    | 7                                 |                            |
| Brazil                          | 55                                       | 3                            | 4                                  | 7                                 |                            |
| Brunei Darussalam               |                                          |                              |                                    | 5                                 |                            |
| Bulgaria                        | 6                                        |                              | 2                                  | 21                                |                            |
| Burkina Faso                    | 10                                       | 1                            |                                    |                                   | 1                          |

| Member State             | No. of research contracts and agreements | No. of Collaborating Centres | Services provided to Member States |                                   |                            |
|--------------------------|------------------------------------------|------------------------------|------------------------------------|-----------------------------------|----------------------------|
|                          |                                          |                              | ALMERA <sup>a</sup>                | Dosimetry audits for radiotherapy | Plant irradiation services |
| Burundi                  |                                          |                              |                                    |                                   |                            |
| Cambodia                 |                                          |                              |                                    | 12                                |                            |
| Cameroon                 | 7                                        |                              |                                    |                                   |                            |
| Canada                   | 37                                       | 1                            | 3                                  | 6                                 |                            |
| Central African Republic |                                          |                              |                                    |                                   | 1                          |
| Chad                     | 2                                        |                              |                                    |                                   |                            |
| Chile                    | 14                                       |                              | 1                                  | 1                                 |                            |
| China                    | 107                                      | 7                            | 3                                  | 41                                |                            |
| Colombia                 | 5                                        |                              |                                    | 1                                 |                            |
| Comoros                  |                                          |                              |                                    |                                   |                            |
| Congo                    |                                          |                              |                                    |                                   |                            |
| Costa Rica               | 10                                       | 1                            | 1                                  |                                   |                            |
| Côte d'Ivoire            |                                          |                              |                                    |                                   |                            |
| Croatia                  | 14                                       |                              | 2                                  | 18                                | 2                          |
| Cuba                     | 11                                       |                              | 3                                  | 11                                |                            |
| Cyprus                   |                                          |                              | 1                                  | 9                                 |                            |
| Czech Republic           | 13                                       |                              | 1                                  | 11                                |                            |
| Dem. Rep. of the Congo   | 1                                        |                              |                                    |                                   | 1                          |
| Denmark                  | 4                                        |                              | 1                                  | 1                                 |                            |
| Djibouti                 |                                          |                              |                                    |                                   |                            |
| Dominica                 |                                          |                              |                                    |                                   |                            |
| Dominican Republic       |                                          |                              |                                    |                                   |                            |
| Ecuador                  | 8                                        |                              | 1                                  | 1                                 |                            |
| Egypt                    | 25                                       | 2                            | 1                                  | 19                                |                            |
| El Salvador              |                                          |                              |                                    |                                   |                            |
| Eritrea                  |                                          |                              |                                    |                                   | 1                          |

| Member State              | No. of research contracts and agreements | No. of Collaborating Centres | Services provided to Member States |                                   |                            |
|---------------------------|------------------------------------------|------------------------------|------------------------------------|-----------------------------------|----------------------------|
|                           |                                          |                              | ALMERA <sup>a</sup>                | Dosimetry audits for radiotherapy | Plant irradiation services |
| Estonia                   | 4                                        |                              | 1                                  | 8                                 |                            |
| Eswatini                  |                                          |                              |                                    |                                   |                            |
| Ethiopia                  | 7                                        |                              | 1                                  | 6                                 |                            |
| Fiji                      |                                          |                              |                                    |                                   |                            |
| Finland                   | 13                                       |                              | 1                                  | 1                                 |                            |
| France                    | 56                                       | 4                            | 5                                  |                                   | 1                          |
| Gabon                     |                                          |                              |                                    |                                   |                            |
| Georgia                   | 1                                        |                              |                                    | 1                                 |                            |
| Germany                   | 46                                       |                              | 4                                  |                                   | 5                          |
| Ghana                     | 22                                       |                              |                                    | 4                                 | 2                          |
| Greece                    | 22                                       |                              | 6                                  | 2                                 | 1                          |
| Grenada                   |                                          |                              |                                    |                                   |                            |
| Guatemala                 | 3                                        |                              |                                    | 6                                 |                            |
| Guyana                    |                                          |                              |                                    |                                   |                            |
| Haiti                     |                                          |                              |                                    |                                   |                            |
| Holy See                  |                                          |                              |                                    |                                   |                            |
| Honduras                  |                                          |                              |                                    |                                   | 1                          |
| Hungary                   | 21                                       | 2                            | 3                                  | 20                                | 1                          |
| Iceland                   |                                          |                              | 1                                  |                                   |                            |
| India                     | 70                                       | 1                            | 3                                  | 32                                | 1                          |
| Indonesia                 | 33                                       | 2                            | 1                                  | 21                                |                            |
| Iran, Islamic Republic of | 21                                       |                              | 4                                  | 2                                 |                            |
| Iraq                      |                                          |                              | 1                                  |                                   | 1                          |
| Ireland                   | 3                                        |                              | 1                                  |                                   |                            |
| Israel                    | 7                                        |                              | 2                                  | 30                                |                            |
| Italy                     | 43                                       | 3                            | 8                                  |                                   |                            |

| Member State           | No. of research contracts and agreements | No. of Collaborating Centres | Services provided to Member States |                                   |                            |
|------------------------|------------------------------------------|------------------------------|------------------------------------|-----------------------------------|----------------------------|
|                        |                                          |                              | ALMERA <sup>a</sup>                | Dosimetry audits for radiotherapy | Plant irradiation services |
| Jamaica                | 4                                        |                              | 1                                  |                                   |                            |
| Japan                  | 37                                       | 5                            | 5                                  | 8                                 |                            |
| Jordan                 | 7                                        |                              | 1                                  | 15                                |                            |
| Kazakhstan             | 2                                        |                              | 1                                  | 41                                |                            |
| Kenya                  | 16                                       |                              | 1                                  | 1                                 | 1                          |
| Korea, Republic of     | 28                                       | 2                            | 2                                  | 20                                |                            |
| Kuwait                 | 5                                        | 1                            | 1                                  | 1                                 | 1                          |
| Kyrgyzstan             | 3                                        |                              |                                    |                                   | 1                          |
| Lao People's Dem. Rep. | 1                                        |                              |                                    |                                   |                            |
| Latvia                 | 1                                        |                              | 1                                  | 5                                 |                            |
| Lebanon                | 6                                        |                              | 1                                  | 12                                |                            |
| Lesotho                |                                          |                              |                                    |                                   |                            |
| Liberia                |                                          |                              |                                    |                                   |                            |
| Libya                  |                                          |                              |                                    |                                   |                            |
| Liechtenstein          |                                          |                              |                                    |                                   |                            |
| Lithuania              | 7                                        |                              | 3                                  | 15                                |                            |
| Luxembourg             | 1                                        |                              | 1                                  |                                   |                            |
| Madagascar             | 1                                        |                              | 1                                  |                                   |                            |
| Malawi                 | 1                                        |                              |                                    |                                   | 1                          |
| Malaysia               | 32                                       | 1                            | 1                                  | 43                                |                            |
| Mali                   |                                          |                              |                                    |                                   |                            |
| Malta                  |                                          |                              |                                    |                                   |                            |
| Marshall Islands       |                                          |                              |                                    |                                   |                            |
| Mauritania             |                                          |                              |                                    | 3                                 | 1                          |
| Mauritius              | 4                                        |                              |                                    |                                   |                            |
| Mexico                 | 34                                       | 2                            | 3                                  | 54                                |                            |
| Monaco                 |                                          |                              |                                    |                                   |                            |

| Member State        | No. of research contracts and agreements | No. of Collaborating Centres | Services provided to Member States |                                   |                            |
|---------------------|------------------------------------------|------------------------------|------------------------------------|-----------------------------------|----------------------------|
|                     |                                          |                              | ALMERA <sup>a</sup>                | Dosimetry audits for radiotherapy | Plant irradiation services |
| Mongolia            | 3                                        |                              | 1                                  |                                   |                            |
| Montenegro          | 1                                        |                              | 1                                  |                                   |                            |
| Morocco             | 20                                       | 2                            | 1                                  | 9                                 |                            |
| Mozambique          | 1                                        |                              |                                    |                                   |                            |
| Myanmar             | 4                                        |                              | 1                                  |                                   |                            |
| Namibia             | 6                                        |                              |                                    | 1                                 | 1                          |
| Nepal               | 2                                        |                              |                                    |                                   |                            |
| Netherlands         | 8                                        | 1                            | 4                                  | 1                                 | 1                          |
| New Zealand         | 5                                        |                              | 1                                  |                                   |                            |
| Nicaragua           | 1                                        |                              |                                    |                                   |                            |
| Niger               |                                          |                              |                                    |                                   |                            |
| Nigeria             | 5                                        |                              | 1                                  | 10                                | 1                          |
| North Macedonia     | 5                                        |                              | 1                                  | 3                                 | 1                          |
| Norway              | 4                                        | 1                            | 2                                  | 2                                 |                            |
| Oman                |                                          |                              |                                    |                                   |                            |
| Pakistan            | 40                                       | 2                            | 1                                  | 1                                 |                            |
| Palau               |                                          |                              |                                    |                                   |                            |
| Panama              |                                          |                              | 1                                  | 7                                 |                            |
| Papua New Guinea    | 1                                        |                              |                                    |                                   |                            |
| Paraguay            |                                          |                              |                                    | 9                                 |                            |
| Peru                | 8                                        | 1                            | 1                                  | 15                                |                            |
| Philippines         | 16                                       |                              | 1                                  | 31                                | 1                          |
| Poland              | 22                                       | 1                            | 6                                  | 7                                 | 3                          |
| Portugal            | 9                                        | 1                            | 1                                  | 1                                 |                            |
| Qatar               | 1                                        |                              | 1                                  |                                   |                            |
| Republic of Moldova | 1                                        |                              |                                    | 2                                 |                            |
| Romania             | 21                                       |                              | 4                                  | 63                                |                            |

| Member State                     | No. of research contracts and agreements | No. of Collaborating Centres | Services provided to Member States |                                   |                            |
|----------------------------------|------------------------------------------|------------------------------|------------------------------------|-----------------------------------|----------------------------|
|                                  |                                          |                              | ALMERA <sup>a</sup>                | Dosimetry audits for radiotherapy | Plant irradiation services |
| Russian Federation               | 55                                       | 1                            | 4                                  | 53                                |                            |
| Rwanda                           |                                          |                              |                                    |                                   |                            |
| Saint Kitts and Nevis            |                                          |                              |                                    |                                   |                            |
| Saint Lucia                      |                                          |                              |                                    |                                   |                            |
| Saint Vincent and the Grenadines |                                          |                              |                                    |                                   |                            |
| Samoa                            |                                          |                              |                                    |                                   |                            |
| San Marino                       |                                          |                              |                                    |                                   |                            |
| Saudi Arabia                     | 4                                        |                              | 2                                  | 24                                | 1                          |
| Senegal                          | 7                                        |                              |                                    | 2                                 |                            |
| Serbia                           | 15                                       |                              | 5                                  | 15                                | 1                          |
| Seychelles                       |                                          |                              |                                    |                                   |                            |
| Sierra Leone                     |                                          |                              |                                    |                                   |                            |
| Singapore                        | 9                                        |                              | 3                                  | 14                                |                            |
| Slovakia                         | 6                                        | 1                            | 3                                  | 5                                 | 2                          |
| Slovenia                         | 13                                       |                              | 1                                  |                                   | 1                          |
| South Africa                     | 36                                       | 1                            | 3                                  | 8                                 |                            |
| Spain                            | 45                                       | 2                            | 2                                  | 3                                 |                            |
| Sri Lanka                        | 10                                       |                              | 1                                  | 24                                |                            |
| Sudan                            | 5                                        |                              |                                    | 1                                 |                            |
| Sweden                           | 16                                       |                              | 2                                  | 11                                |                            |
| Switzerland                      | 11                                       | 2                            | 3                                  |                                   |                            |
| Syrian Arab Republic             | 5                                        |                              | 1                                  | 1                                 |                            |
| Tajikistan                       |                                          |                              | 1                                  |                                   |                            |
| Thailand                         | 25                                       | 1                            | 2                                  | 63                                |                            |
| Togo                             |                                          |                              |                                    |                                   |                            |
| Tonga                            |                                          |                              |                                    |                                   |                            |

| Member State                      | No. of research contracts and agreements | No. of Collaborating Centres | Services provided to Member States |                                   |                            |
|-----------------------------------|------------------------------------------|------------------------------|------------------------------------|-----------------------------------|----------------------------|
|                                   |                                          |                              | ALMERA <sup>a</sup>                | Dosimetry audits for radiotherapy | Plant irradiation services |
| Trinidad and Tobago               | 1                                        |                              |                                    | 17                                |                            |
| Tunisia                           | 24                                       |                              | 1                                  | 20                                |                            |
| Türkiye                           | 24                                       |                              | 2                                  | 18                                |                            |
| Turkmenistan                      |                                          |                              |                                    |                                   |                            |
| Uganda                            | 8                                        |                              |                                    |                                   |                            |
| Ukraine                           | 23                                       |                              | 1                                  | 37                                |                            |
| United Arab Emirates              | 3                                        | 1                            | 4                                  | 8                                 |                            |
| United Kingdom                    | 45                                       | 2                            | 6                                  | 13                                | 4                          |
| United Republic of Tanzania       | 6                                        |                              |                                    | 1                                 | 1                          |
| United States of America          | 105                                      | 1                            | 7                                  | 16                                |                            |
| Uruguay                           | 8                                        |                              | 1                                  | 9                                 |                            |
| Uzbekistan                        | 1                                        |                              | 1                                  | 21                                |                            |
| Vanuatu                           |                                          |                              |                                    |                                   |                            |
| Venezuela, Bolivarian Republic of |                                          |                              | 2                                  | 53                                |                            |
| Viet Nam                          | 25                                       |                              | 3                                  | 38                                |                            |
| Yemen                             |                                          |                              |                                    |                                   |                            |
| Zambia                            | 9                                        |                              | 1                                  |                                   |                            |
| Zimbabwe                          | 4                                        |                              |                                    | 2                                 |                            |

<sup>a</sup> ALMERA: Analytical Laboratories for the Measurement of Environmental Radioactivity.

**Table A14. Advisory Missions on Regulatory Infrastructure for Radiation Safety and Nuclear Security (RISS) in 2022**

| Type | Country                          |
|------|----------------------------------|
| RISS | Bolivia                          |
| RISS | Democratic Republic of the Congo |
| RISS | Djibouti                         |
| RISS | Gabon                            |
| RISS | Seychelles                       |
| RISS | Uruguay                          |

**Table A15. Education and Training Appraisal (EduTA) missions in 2022**

| Type  | Country |
|-------|---------|
| EduTA | Nigeria |

**Table A16. Emergency Preparedness Review (EPREV) missions in 2022**

| Type            | Country  |
|-----------------|----------|
| EPREV           | Morocco  |
| EPREV follow-up | Hungary  |
| EPREV follow-up | Slovenia |

**Table A17. IAEA-designated International Centres based on Research Reactors (ICERRs)**

| Type  | Organization/research centre                                                                                                        | Country                  | Year of designation/redesignation |
|-------|-------------------------------------------------------------------------------------------------------------------------------------|--------------------------|-----------------------------------|
| ICERR | Institute for Nuclear Research Pitești                                                                                              | Romania                  | 2020                              |
| ICERR | Korea Atomic Energy Research Institute                                                                                              | Republic of Korea        | 2019                              |
| ICERR | Nuclear Research Centre SCK CEN                                                                                                     | Belgium                  | 2017                              |
| ICERR | Idaho and Oak Ridge National Laboratories of the US Department of Energy                                                            | United States of America | 2017                              |
| ICERR | Research Institute of Atomic Reactors                                                                                               | Russian Federation       | 2016/2022                         |
| ICERR | Alternative Energies and Atomic Energy Commission, in partnership with the Institute for Radiological Protection and Nuclear Safety | France                   | 2015/2020                         |



**Table A18. Independent Safety Culture Assessment (ISCA) missions in 2022**

| Type | Country |
|------|---------|
| ISCA | Brazil  |

**Table A19. Integrated missions of the Agency's Programme of Action for Cancer Therapy (imPACT) in 2022**

| Type   | Country                          |
|--------|----------------------------------|
| imPACT | Colombia                         |
| imPACT | Lao People's Democratic Republic |
| imPACT | Syrian Arabic Republic           |
| imPACT | Uzbekistan                       |

**Table A20. Integrated Nuclear Infrastructure Review (INIR) missions in 2022**

| Type         | Country   |
|--------------|-----------|
| INIR Phase 1 | Sri Lanka |

**Table A21. Integrated Nuclear Infrastructure Review for Research Reactors (INIR-RR) missions in 2022**

| Type              | Country |
|-------------------|---------|
| INIR-RR follow-up | Nigeria |

**Table A22. Integrated Regulatory Review Service (IRRS) missions in 2022**

| Type           | Country                |
|----------------|------------------------|
| IRRS           | Argentina              |
| IRRS           | Bangladesh             |
| IRRS           | Bosnia and Herzegovina |
| IRRS           | Finland                |
| IRRS           | Portugal               |
| IRRS           | Singapore              |
| IRRS           | Slovakia               |
| IRRS           | Slovenia               |
| IRRS           | Sweden                 |
| IRRS           | Türkiye                |
| IRRS follow-up | India                  |
| IRRS follow-up | Pakistan               |
| IRRS follow-up | Zimbabwe               |

**Table A23. Integrated Research Reactor Utilization Review (IRRUR) missions in 2022**

| Type  | Country      |
|-------|--------------|
| IRRUR | Chile        |
| IRRUR | Peru         |
| IRRUR | South Africa |

**Table A24. Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) missions in 2022**

| Type              | Country   |
|-------------------|-----------|
| ARTEMIS           | Austria   |
| ARTEMIS           | Cyprus    |
| ARTEMIS           | Denmark   |
| ARTEMIS           | Finland   |
| ARTEMIS           | Hungary   |
| ARTEMIS           | Lithuania |
| ARTEMIS           | Malta     |
| ARTEMIS           | Romania   |
| ARTEMIS           | Slovenia  |
| ARTEMIS follow-up | Germany   |

**Table A25. International Nuclear Management Academy (INMA) missions in 2022**

| Type | Organization/research centre                | Country                  |
|------|---------------------------------------------|--------------------------|
| INMA | University of West Bohemia                  | Czech Republic           |
| INMA | KEPCO International Nuclear Graduate School | Republic of Korea        |
| INMA | University of Idaho                         | United States of America |

**Table A26. International Nuclear Security Advisory Service (INSServ) missions in 2022**

| Type    | Country  |
|---------|----------|
| INSServ | Jordan   |
| INSServ | Malaysia |
| INSServ | Sudan    |

**Table A27. International Physical Protection Advisory Service (IPPAS) missions in 2022**

| Type  | Country |
|-------|---------|
| IPPAS | Finland |

Table A28. Knowledge Management Assist Visits (KMAVs) in 2022

| Type | Nuclear organization <sup>a</sup>                                                                        | Country              |
|------|----------------------------------------------------------------------------------------------------------|----------------------|
| KMAV | Chilean Nuclear Energy Commission                                                                        | Chile                |
| KMAV | Ethiopian Government ministries                                                                          | Ethiopia             |
| KMAV | National Research and Innovation Agency                                                                  | Indonesia            |
| KMAV | Jordan Atomic Energy Commission                                                                          | Jordan               |
| KMAV | National Commission for Science, Technology and Innovation; Kenyatta University                          | Kenya                |
| KMAV | Nuclear Power and Energy Agency                                                                          | Kenya                |
| KMAV | University of Mauritius                                                                                  | Mauritius            |
| KMAV | Laguna Verde NPP                                                                                         | Mexico               |
| KMAV | Nigeria Atomic Energy Commission                                                                         | Nigeria              |
| KMAV | Rwanda Atomic Energy Board                                                                               | Rwanda               |
| KMAV | Department of Mineral Resources and Energy                                                               | South Africa         |
| KMAV | Atomic Energy Commission of Syria                                                                        | Syrian Arab Republic |
| KMAV | National Centre for Nuclear Science and Technology                                                       | Tunisia              |
| KMAV | National Centre for Nuclear Science and Technology; University of Carthage; University of Tunis El Manar | Tunisia              |

<sup>a</sup> Nuclear organizations include operators, regulators, technical support organizations and education providers.

Table A29. Occupational Radiation Protection Appraisal Service (ORPAS) missions in 2022

| Type            | Country              |
|-----------------|----------------------|
| ORPAS           | Nigeria              |
| ORPAS           | Philippines          |
| ORPAS           | Slovakia             |
| ORPAS follow-up | Costa Rica           |
| ORPAS follow-up | Morocco              |
| ORPAS follow-up | Peru                 |
| ORPAS follow-up | United Arab Emirates |

**Table A30. Operation and Maintenance Assessment for Research Reactors (OMARR) missions in 2022**

| Type  | Country |
|-------|---------|
| OMARR | Chile   |
| OMARR | Poland  |

**Table A31. Operational Safety Review Team (OSART) missions in 2022**

| Type            | Country                  |
|-----------------|--------------------------|
| OSART           | France                   |
| OSART           | Republic of Korea        |
| OSART follow-up | France                   |
| OSART follow-up | Islamic Republic of Iran |
| OSART follow-up | United Arab Emirates     |

**Table A32. Peer Reviews of Operational Safety Performance Experience (PROSPER) in 2022**

| Type    | Country   |
|---------|-----------|
| PROSPER | Argentina |

**Table A33. Safety Aspects of Long Term Operation (SALTO) missions in 2022**

| Type            | Country      |
|-----------------|--------------|
| SALTO           | South Africa |
| SALTO           | Sweden       |
| SALTO follow-up | Brazil       |
| SALTO follow-up | Mexico       |

**Table A34. Safety Culture Continuous Improvement Process (SCCIP) missions in 2022**

| Type  | Country |
|-------|---------|
| SCCIP | Poland  |

**Table A35. Site and External Events Design (SEED) missions in 2022**

| Type           | Country        |
|----------------|----------------|
| SEED           | Czech Republic |
| SEED           | Romania        |
| SEED follow-up | Czech Republic |

**Table A36. Technical Safety Reviews (TSRs) in 2022**

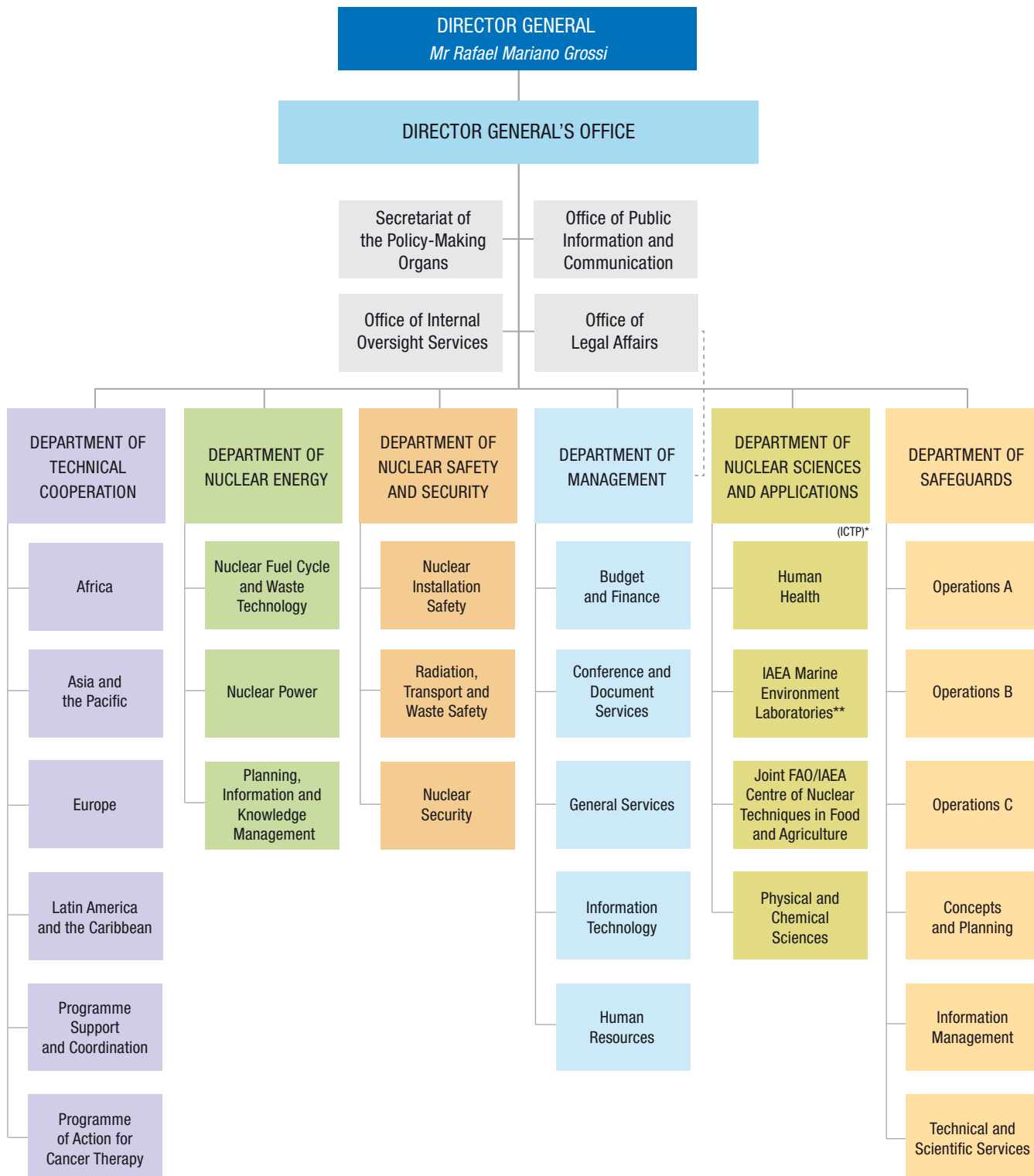
| Type                            | Country      |
|---------------------------------|--------------|
| Probabilistic Safety Assessment | Mexico       |
| Periodic Safety Review          | South Africa |

**Table A37. Uranium Production Site Appraisal Team (UPSAT) missions in 2022**

| Type  | Organization              | Country  |
|-------|---------------------------|----------|
| UPSAT | Nuclear Energy Commission | Mongolia |

# ORGANIZATIONAL CHART

(as of 31 December 2022)



\* The Abdus Salam International Centre for Theoretical Physics (ICTP), legally referred to as the "International Centre for Theoretical Physics", is operated as a joint programme by UNESCO and the Agency. Administration is carried out by UNESCO on behalf of both organizations.

\*\* With the participation of UNEP and IOC.

*“The Agency shall seek to accelerate and enlarge  
the contribution of atomic energy to peace, health  
and prosperity throughout the world.”*

**Article II of the IAEA Statute**

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