IAEA BULLETIN

INTERNATIONAL ATOMIC ENERGY AGENCY

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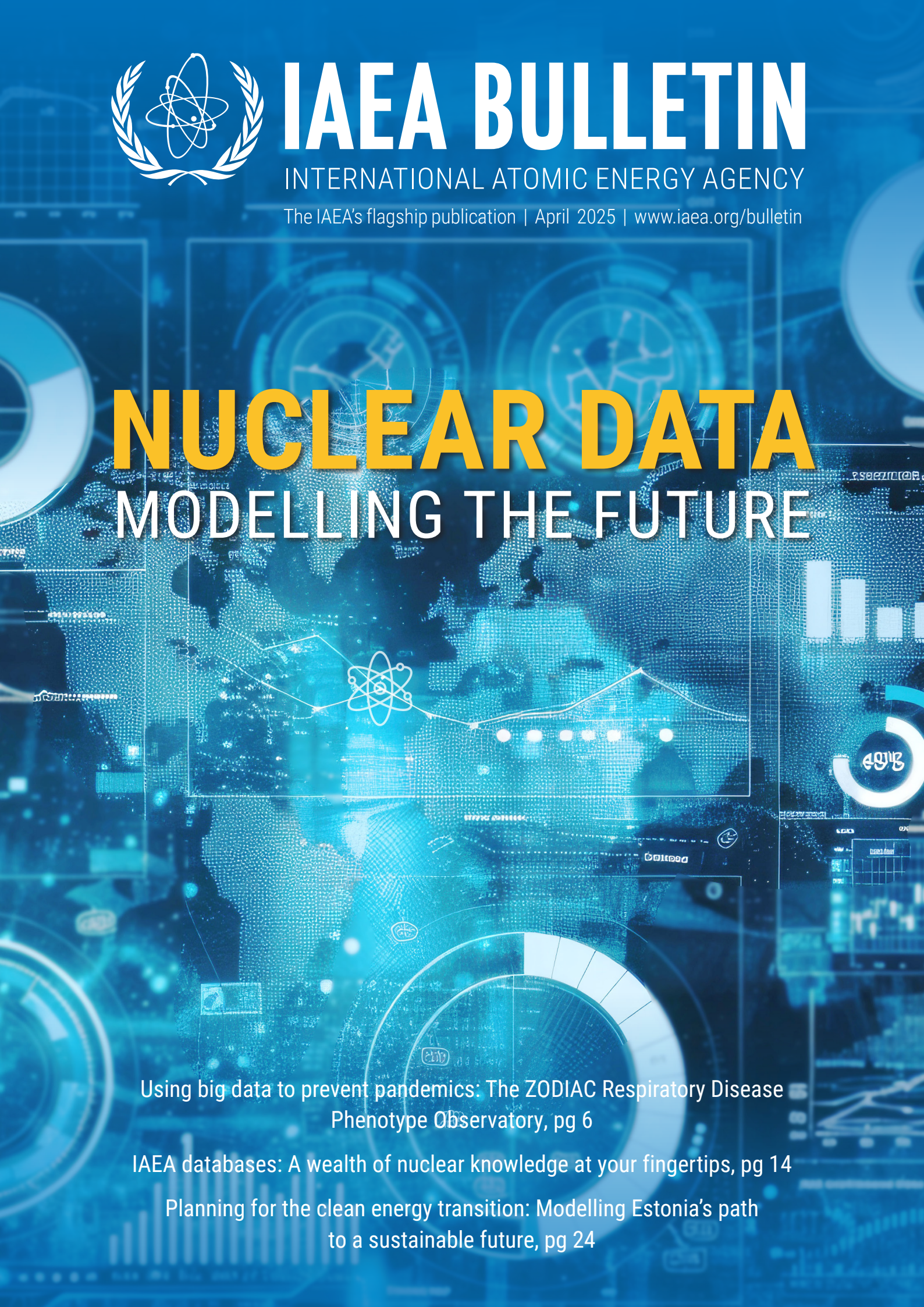
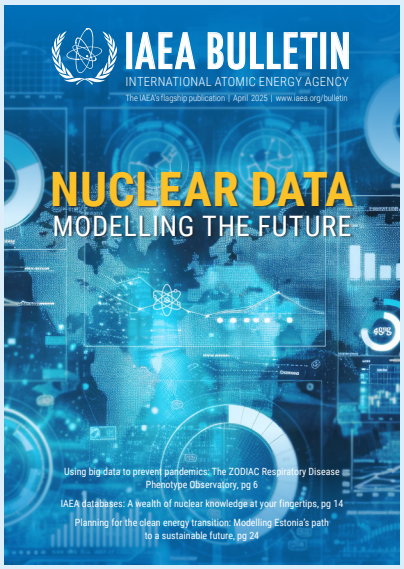


NUCLEAR DATA

MODELLING THE FUTURE



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The mission of the **International Atomic Energy Agency** (IAEA) is to help prevent the spread of nuclear weapons and to help all countries — especially in the developing world — benefit from the peaceful, safe and secure use of nuclear science and technology.

Established as an autonomous organization under the United Nations in 1957, the IAEA is the only organization within the UN system with expertise in nuclear technologies. The IAEA's unique specialist laboratories help transfer knowledge and expertise to IAEA Member States in areas such as human health, food, water, industry and the environment.

The IAEA also serves as the global platform for strengthening nuclear security. The IAEA has established the Nuclear Security Series of international consensus guidance publications on nuclear security. The IAEA's work also focuses on helping to minimize the risk of nuclear and other radioactive material falling into the hands of terrorists and criminals, or of nuclear facilities being subjected to malicious acts.

The IAEA safety standards provide the fundamental principles, requirements and recommendations to ensure nuclear safety and reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from the harmful effects of ionizing radiation. The IAEA safety standards have been developed for all types of nuclear facilities and activities that serve peaceful purposes, as well as for protective actions to reduce existing radiation risks.

The IAEA also verifies through its inspection system that Member States comply with their commitments under the Nuclear Non-Proliferation Treaty and other non-proliferation agreements to use nuclear material and facilities only for peaceful purposes.

The IAEA's work is multi-faceted and engages a wide variety of partners at the national, regional and international levels. IAEA programmes and budgets are set through decisions of its policymaking bodies — the 35-member Board of Governors and the General Conference of all Member States.

The IAEA is headquartered at the Vienna International Centre, Vienna, Austria. Field and liaison offices are located in Geneva, New York, Tokyo and Toronto. The IAEA operates scientific laboratories in Monaco, Seibersdorf and Vienna. In addition, the IAEA supports and provides funding to the Abdus Salam International Centre for Theoretical Physics, in Trieste, Italy.

Nuclear data: Fuel for human ingenuity and global progress

By Rafael Mariano Grossi, IAEA Director General

From dry fields to melting glaciers, IAEA scientists and experts are collecting, analysing and sharing data to advance peace, security and sustainable development.

Data help us to identify the root causes of major challenges facing the world today and to design effective solutions. In the nuclear field, data are essential for research and development as well as policy. They not only expand our knowledge but enable us to measure impact, monitor progress and identify successful strategies and technologies. By collecting and sharing data, the IAEA fosters international collaboration and fact based policy decisions that benefit everyone.

This issue of the *IAEA Bulletin* shows how data underpin the Agency's work across the many sectors in which we are active — from health and nutrition to agriculture and the environment, from energy to nuclear safety and security — and highlights the diverse array of IAEA databases supporting the work of scientists and policymakers around the world.

This *Bulletin* is full of fascinating stories. Our efforts range from the micro to the macro — from collecting samples by hand in the frozen landscape of Antarctica to using artificial intelligence (AI) and machine learning to analyse 'big data'.

In these pages, you can read about a Bolivian scientist who trekked for six days to install technology on a glacier in Nepal, enabling local scientists to collect data on glacier melt and monitor its potential impact on the country's soil and water resources. Or you can learn how an IAEA database helped German security officials protect stadiums in the ten German cities that hosted the UEFA European Football Championship EURO 2024.

Data are the foundation for evidence based approaches, and countries rely on IAEA data, analytical tools and support for planning. For example, Malawi benefited from IAEA data and analysis, as well as support from the Rays of Hope initiative, to plan and build its first public cancer treatment centre. Estonia used an Agency tool for analysing energy systems to develop a model for achieving net zero emissions.

Data are crucial to scientific discovery. To advance the progress of fusion energy from experimentation to commercialization, the IAEA collects and shares data on all phases of research and development, from the science of the fusion process to plant design and operation.

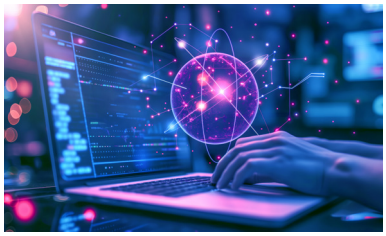
This edition of the *IAEA Bulletin* also highlights how AI and machine learning can enhance research and analysis, thereby expanding knowledge and accelerating progress. For example, the IAEA's Zoonotic Disease Integrated Action (ZODIAC) flagship initiative will use AI and machine learning to identify patterns in zoonotic respiratory diseases, which jump from animals to humans, to detect the emergence of new variants that could cause pandemics.

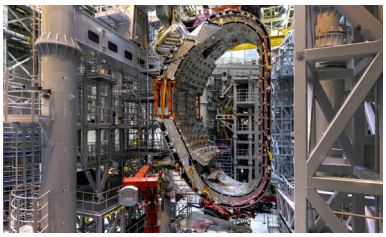
AI is quickly becoming an essential tool for science and industry, and the nuclear sector is no exception. In fact, nuclear power could play an important role as AI continues to become more central to our lives. In 2022, data centres that power AI consumed about 460 terawatt-hours (TW h) globally; this amount is about what it takes to power France for a year. In December, the IAEA will convene an international symposium to explore how nuclear energy can help meet growing demand for electricity from data centres, as well as how AI can support the nuclear power industry.

Data are a critical resource because they fuel ingenuity. In promoting international collaboration in collecting and using data, the IAEA is helping to advance knowledge that can help us tackle shared challenges and build a better future for all.

"By collecting and sharing data, the IAEA fosters international collaboration and fact based policy decisions that benefit everyone."

— Rafael Mariano Grossi, IAEA Director General





IAEA UPDATES

From the Andes to the Himalayas

Understanding the impact of glacier retreat on soil and water

By Emma Midgley

The cosmic ray neutron sensor was assembled on the Yala Glacier in Nepal after a six-day trek.

(Photo: Edson Ramírez/Higher University of San Andrés, Bolivia)

Standing on the Yala Glacier in Nepal in late November at the end of a six-day trek across the frozen Himalayas, Bolivian scientist Edson Ramírez manoeuvred a cosmic ray neutron sensor (CRNS) into place. As soon as it was installed, it began to transmit information via satellite, giving accurate, real-time data on the snow accumulation on the glacier.

In Sanskrit, the word Himalaya means 'abode of snow'. But as global warming has accelerated, glaciers on the vast Central Asian mountain range have started to melt, weaken, collapse and disappear at unprecedented rates.

CRNSs work by measuring neutrons near the soil surface and over a large area, enabling scientists to take exact measurements of the moisture levels of snow and soil. These data can be used to show whether glaciers are accumulating enough snow to survive the warmer months, or whether wetlands are drying up. Innovative IAEA research and development activities conducted through the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture (Joint FAO/IAEA Centre) have supported the development of these neutron sensors enabling scientists to use this tool to improve climate-related emergency preparedness.

Prior to the installation of the CRNSs on the Yala Glacier, scientists in Nepal relied on monthly or yearly readings to find out how the glacier was changing, but now they receive regular updates on the latest changes to snow accumulation. Regular and consistent provision of such data can inform strategies and policies to help the country adapt to future water scarcity.

Ramírez, a glaciologist at the Higher University of San Andrés in Bolivia, received training in the use of CRNS data under an IAEA technical cooperation (TC) programme, as part of a decade of IAEA projects to build countries' capacity to assess the effects of climate change in glacial and polar regions using nuclear techniques. "Travelling to Nepal gave me the opportunity to share my expertise with scientists in other regions," said Ramírez. "The CRNS will help scientists understand better how the glacier is changing over time, and its potential impact on soil and water resources."

The disappearance of snow and ice has serious consequences in Nepal. Millions of people rely on water from glacial melt or snow-melt. When these water sources dry up, entire villages are abandoned. As glaciers disappear, there is also the risk that soil will become unstable, creating erosion and landslides and making farming impossible.

Before travelling to Nepal, Ramírez, working with the IAEA, helped install the highest CRNS in the world to measure snow accumulation and its water equivalent on Bolivia's Huayna Potosí mountain peak, 4500 metres above sea level, where communities are also experiencing water scarcity due to glacier loss. In the same watershed, another CRNS monitors soil moisture in high altitude wetlands. These watersheds are critical carbon reservoirs that play a key role in buffering regional water supplies, and are therefore particularly vulnerable to climate change.

Working in mountainous and polar regions such as Antarctica and the Arctic, IAEA experts have also trained local scientists in the use of isotopic analysis and complementary methods to reconstruct how historical changes in climate have affected these regions over millennia. Chemical and isotopic 'fingerprints' can reveal how glacial melt has affected the movement and quality of soil, enabling countries to prepare for the future.

"We have to understand the driving factors behind climate change and its impact on soil and water resources by examining historical patterns," said Gerd Dercon, Head of the Soil, Water Management and Crop Nutrition Section at the Joint FAO/IAEA Centre. "Will climate change trigger feedback loops that accelerate global warming, for example by reducing surface reflectivity due to diminished snow and ice cover? By studying the past, we can better understand the future."

The IAEA is delivering a series of projects related to climate change in polar and mountainous regions. So far, it has trained scientists from 14 countries. A team comprising these scientists and IAEA experts has participated in 15 scientific expeditions across the world. These training opportunities and expeditions — from King George Island in Antarctica to the Norwegian archipelago of Svalbard in the Arctic, and from the Andes to the eastern Tibetan Plateau — are striking examples of South–South and triangular cooperation in action: a key delivery mechanism for the TC programme.

An important outcome of these expeditions has been the establishment of an international monitoring network, with an IAEA-hosted e-learning platform providing education and training in the storage, sharing and visualization of data. The network has uncovered previously unknown processes in soil organic carbon and sediment redistribution, and has provided insights into how the parts of the world covered by ice (known as the 'cryosphere') are impacted by climate change.

Nearly two billion people — a quarter of the global population — live in areas where glaciers and seasonal snow-melt supply them with water. Climate change is already affecting water and food security, potentially threatening some of the world's most fragile ecosystems and underscoring the importance of accurate, real-time data to help the world adapt to life on a warming planet.

"The cosmic ray neutron sensor will help scientists better understand how the glacier is changing over time, and its potential impact on soil and water resources."

— Edson Ramírez, a glaciologist at the Higher University of San Andrés in Bolivia, with the newly installed CRNS on the Yala Glacier in Nepal.

(Photo: Tribhuvan University, Nepal)

Using big data to prevent pandemics

The ZODIAC Respiratory Disease Phenotype Observatory

By Enrique Estrada Lobato and Mary Albon

The **ZODIAC Respiratory Disease Phenotype Observatory** will use radiomics, a method for extracting large scale imaging data, or big data, from medical imaging studies.

Scan to learn more

Every year, around 2.6 billion people are affected by diseases originating in animals (zoonotic diseases). To prevent pandemics, it is essential to detect and characterize zoonotic diseases before an outbreak occurs, or at an early stage.

As part of the IAEA's Zoonotic Disease Integrated Action (ZODIAC) initiative launched in 2020, the ZODIAC Respiratory Disease Phenotype Observatory will create a secure medical imaging repository to foster global cooperation on large scale data analysis of disease patterns, enabling the early detection of zoonotic diseases that could potentially cause pandemics.

The observatory will use artificial intelligence (AI), including machine learning and deep learning, to identify the patterns of respiratory diseases such as Middle East respiratory syndrome (MERS), severe acute respiratory syndrome (SARS), COVID-19 and pneumonia and detect the emergence of new variants.

"The IAEA's ZODIAC Respiratory Disease Phenotype Observatory will play an important role in identifying the emergence of new infectious diseases around the world, monitoring their spread and facilitating the rapid development of AI models for treatment support," said Professor Georg Langs, Head of the Computational Imaging Research Lab at the Medical University of Vienna, one of the project's core laboratories. "Because it works with research institutions across the globe, the observatory will be able to analyse a much larger and more demographically diverse collection of data on respiratory diseases than previous studies."

Medical imaging and big data

Medical imaging plays a crucial role in diagnosing and monitoring infectious diseases. However, images can be challenging to analyse because of their complexity.

The ZODIAC Respiratory Disease Phenotype Observatory will use radiomics, a method for extracting large scale imaging data, or big data, from medical imaging studies. Radiomics uses data characterization algorithms to identify disease findings, increasing diagnostic accuracy and aiding individualized therapy planning.

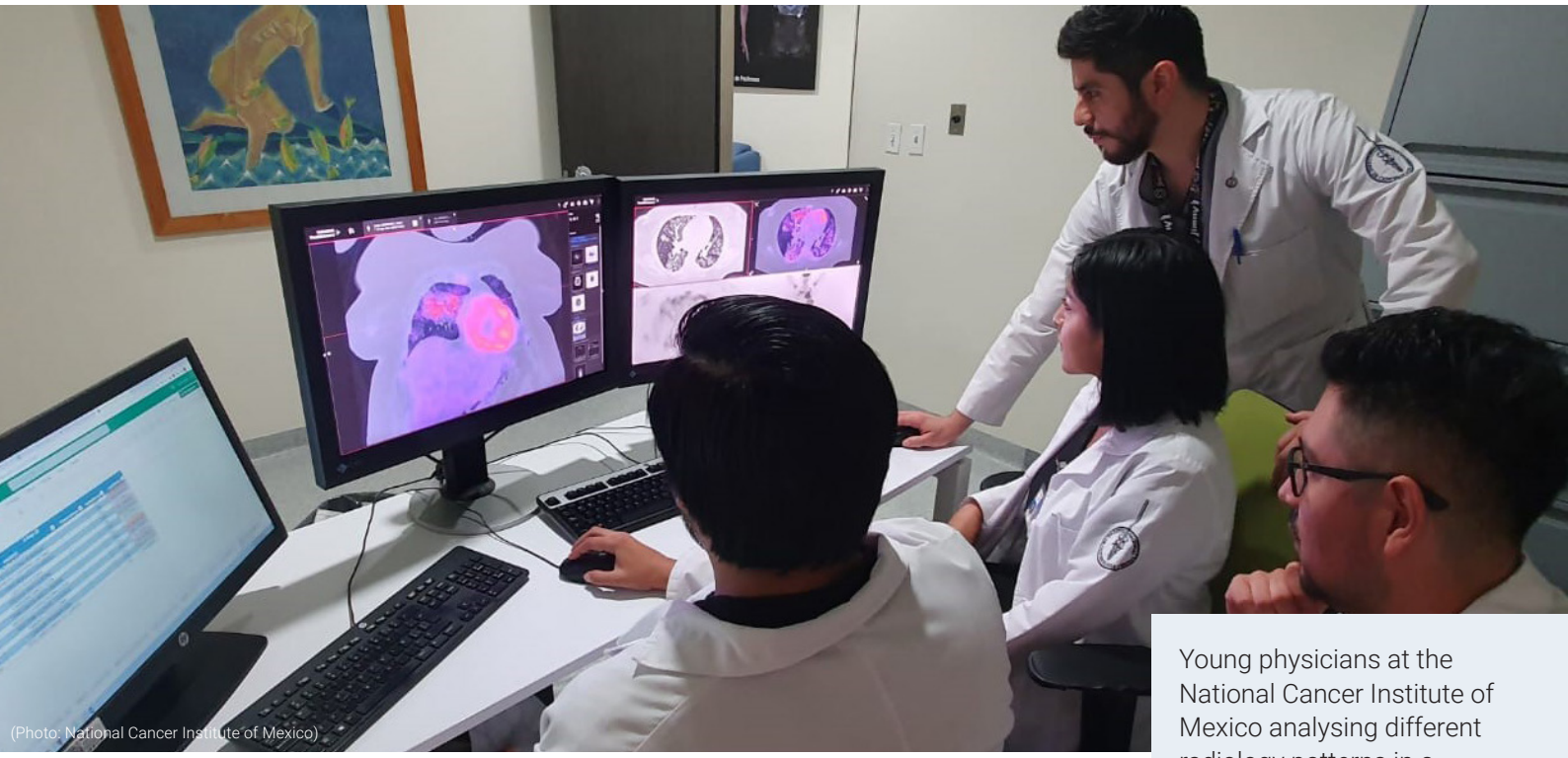
AI can complement radiomics by identifying disease patterns and anomalies in large volumes of data. These techniques can also be used to identify the patterns of emerging diseases, which can help to prevent outbreaks of novel diseases developing into pandemics.

The ZODIAC Respiratory Disease Phenotype Observatory

In its first two years, the observatory will create a medical imaging repository and use it to develop and validate algorithms for analysing imaging data. It will evaluate

Professor Georg Langs of the Medical University of Vienna shows how AI algorithms can be used to analyse computed tomography (CT) images of the lungs.

(Photo: Medical University of Vienna)


(Photo: National Cancer Institute of Mexico)

Young physicians at the National Cancer Institute of Mexico analysing different radiology patterns in a CT study of a patient with COVID-19.

studies conducted by 20 research institutions around the world, and will enable research groups to investigate and develop novel AI methods. The observatory's AI-based surveillance for emerging diseases will function automatically, triggering an alert when algorithms detect a new pattern. It will enable the rapid comparison and evaluation of incoming data so as to identify the emergence of new diseases that could develop into pandemics and ensure a timely response.

The observatory will also analyse the demographics of new infectious respiratory diseases. By identifying disease characteristics and specific manifestations in medical imaging, the observatory can help to identify any clinical differences in the development of disease complications, based on factors such as age, sex, race, ethnicity, geographical region and pre-existing medical conditions.

Created through an IAEA coordinated research project, the ZODIAC Respiratory Disease Phenotype Observatory is supported by many partners who provide resources and tools in their respective areas of expertise.

Amazon Web Services (AWS), one of the project's lead supporters, has awarded an AWS Grand Challenges grant for a cloud based server to support the observatory.

"We see this as an important investment in prevention to help protect human health globally," said Chris Russ, Senior Solutions Architect at AWS. "By leveraging the cloud, the IAEA's ZODIAC Observatory can spot emerging pandemics in real time and alert governments to take action."

In addition to the contribution from AWS, in-kind support for the observatory includes database management and components provided by Radboud University Medical Centre; back end curation and web interface provided by the Fraunhofer Institute for Digital Medicine; AI development in identifying disease patterns supported by contextflow GmbH; and scientific and medical expertise provided by the Medical University of Vienna. Participating research institutions include hospitals in 19 countries. The project is also supported by the Republic of Korea.

"The ZODIAC Observatory has a global scope, so we rely on collaboration with and support from scientific and industry partners around the world," said Najat Mokhtar, IAEA Deputy Director General and Head of the Department of Nuclear Sciences and Applications. "By working together, by sharing data and expertise, we can strengthen countries' capacity to respond faster and more effectively to emerging diseases and to prevent them from developing into new pandemics."

IAEA ZODIAC

initiative will strengthen the preparedness and capabilities of Member States to rapidly detect and timely respond to zoonotic diseases.

Scan to learn more

How data collection led to Malawi's first public radiotherapy centre

By Ellen Swabey-Van de Borne and Felix Omanja Wanjala

Malawi is putting the finishing touches to its new public radiotherapy centre in Lilongwe and preparing to diagnose and treat cancer patients domestically for the first time in its history.

"The opening of this treatment centre marks the beginning of a new era for my country," said Sanderson Kuyeli, Deputy Director of Planning (Health Infrastructure Management) in Malawi's Ministry of Health. "We no longer need to send our cancer patients abroad, but can look after them right here, close to their families."

The new radiotherapy centre, which is expected to open by the end of this year, is guided by an evidence based approach and backed by IAEA expertise and support.

Malawi's landmark success owes much to its rigorous data collection efforts, the sustained commitment of the Ministry of Health, and the support of the IAEA and its partners. The country's evidence based approach enabled it to develop a strategic funding proposal and consequently secure a loan from the OPEC Fund for International Development in 2018.

"It all started with an imPACT Review mission in 2012," said Shaukat Abdulrazak, Director of the IAEA Division for Africa. "This first fact-finding mission, conducted jointly by the IAEA, the World Health Organization and the International Agency for Research on Cancer, provided Malawi with a baseline situation analysis and a set of recommendations to guide cancer control planning and investments across the spectrum, from prevention to palliative care."

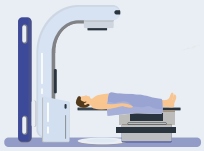
"For over 65 years, our human health specialists have collected data on

DIRAC
is the world's most comprehensive database on radiotherapy resources.

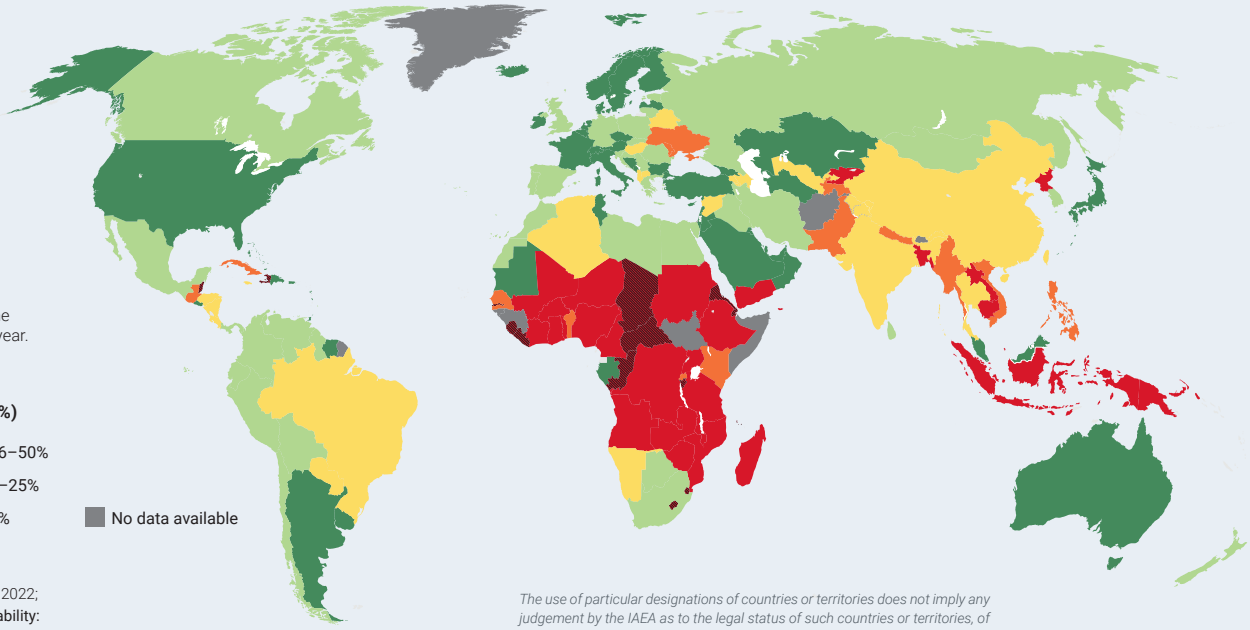
Scan to learn more

Global Radiotherapy Availability

Availability of radiotherapy machines per cancer population*



Assumptions
- 50% of cancer patients require radiotherapy.
- One radiotherapy machine can treat 500 patients a year.



***Sources**
Cancer incidence: Globocan 2022;
Radiotherapy machine availability: DIRAC October 2024 & imPACT Reviews

The use of particular designations of countries or territories does not imply any judgement by the IAEA as to the legal status of such countries or territories, of their authorities and institutions or of the delimitation of their boundaries.

Malawi's new facility has

4 radiotherapy bunkers
2 brachytherapy bunkers
2 linear accelerators
1 cobalt-60 unit
1 computed tomography simulator
1 brachytherapy suite

(Photo: M. Kumwembe/Kamazu Central Hospital, Lilongwe)

radiotherapy access through our Directory of Radiotherapy Centres (DIRAC). They have also helped countries establish and expand their capacities in using ionizing radiation to tackle pressing health challenges safely and effectively," said May Abdel-Wahab, Director of the IAEA Division of Human Health. "The IAEA's extensive support to Malawi is an example of the effective support our specialists provide through their expertise — assistance that is now being delivered through Rays of Hope, the IAEA's initiative to expand cancer care access globally."

Based on the data collected, the IAEA's Human Health Programme provided technical support to build the radiotherapy centre. This covered all steps from bunker design to equipment specifications, procurement and coordination with vendors to ensure that installation and commissioning were completed in a timely manner.

Malawi's new facility has 4 radiotherapy bunkers and 2 brachytherapy bunkers, and will commence operations with 2 linear accelerators, a cobalt-60 unit, a computed tomography simulator and a brachytherapy suite. The IAEA has also trained over 20 specialized medical staff and Atomic Energy Regulatory Authority personnel responsible for inspecting and licensing the new radiotherapy facility.

"We are a testimony of what the IAEA is doing in terms of training young scientists in nuclear-related fields, providing expert services and procuring radiotherapy equipment," said Malawi's Minister of Health, Khumbize Kandodo Chiponda, at the 67th IAEA General Conference in 2023. "As a country, we are delighted that very soon we will be able to treat our cancer patients in Malawi."

"The IAEA helps its Member States to gain a full understanding of their country's cancer control capacity and needs," said Lisa Stevens, Director of the IAEA's Programme of Action for Cancer Therapy. For example, the IAEA's global radiotherapy availability map, which was developed using data from DIRAC and other sources, compares the availability of radiotherapy machines in each country with the need for radiotherapy treatment, which half of all adult cancer patients require.

"Tools such as these remind us of the unequal access to cancer care and how it affects patients in low- and middle-income countries more markedly than in other parts of the world," added Stevens.

DIRAC, the world's most comprehensive database on radiotherapy resources, supports countries in taking evidence based decisions to improve access to cancer care. It can be used to assess existing infrastructure in radiotherapy, plan new radiation oncology centres, and analyse the performance and quality of radiotherapy services. Data on all forms of cancer control is collected during imPACT Reviews and provides insights that are crucial to Rays of Hope and its efforts to close the global gap in cancer care.

For more information on

IAEA RAYS OF HOPE
CANCER CARE FOR ALL

and to explore partnership opportunities with the IAEA, scan here

Tracking microplastics in ice

Scientists collect data in Antarctica with implications for ocean health

By Wolfgang Picot

"No words of mine can convey the impressiveness of the wonderful panorama displayed to our eyes," wrote legendary polar explorer Robert Falcon Scott in his journal during an expedition to Antarctica in January 1911. Marc Metian, François Oberhaensli and Carlos Alonso, IAEA experts who ventured to the seventh continent in January 2024, echo his sentiment. "The icebergs, the constantly changing weather, the wildlife — it's simply amazing how all of these elements come together in this extreme environment," said Metian.

More than a century ago, Falcon Scott faced a landscape untouched by humans. Today, global pollution is reaching even Earth's most remote regions, and Antarctica is no exception. To learn more about the problem of marine pollution, the scientists embarked on the IAEA's first research expedition to Antarctica to investigate the presence of microplastics on and around the white continent. Organized by the Argentine Antarctic Institute, the journey led them some 15 000 kilometres from their workplace at the IAEA Marine Environment Laboratories in Monaco.

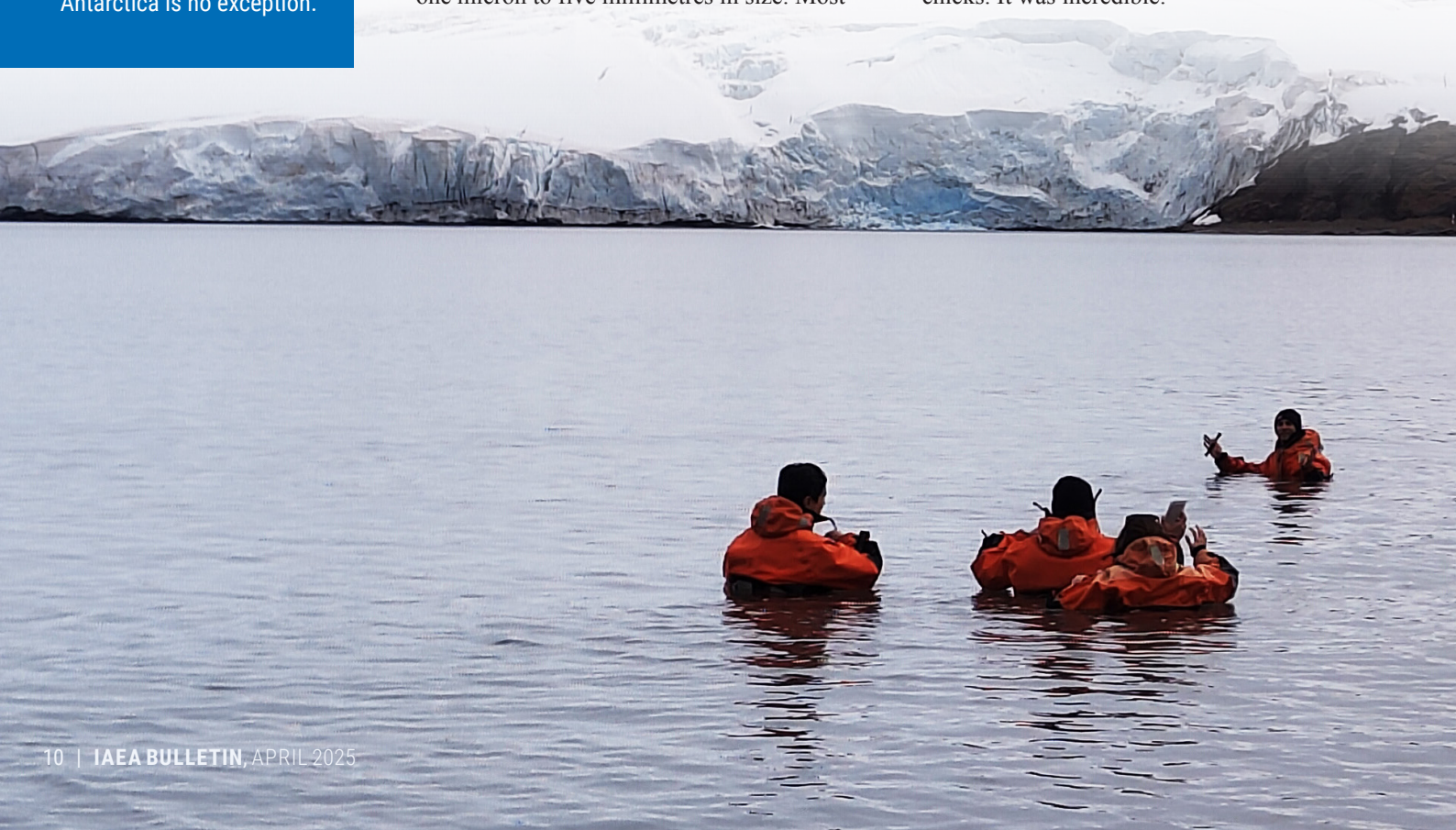
Today, global pollution is reaching even Earth's most remote regions, and Antarctica is no exception.

"Microplastics are particles ranging from one micron to five millimetres in size. Most research is done on larger fragments, while we focused on extremely small materials, starting from 20 microns," explained Oberhaensli, highlighting the mission's unique approach to detecting pollution at unprecedented scales.

Moving around by helicopter, military cargo plane and icebreaker, the scientists collected samples from 22 different sites. The specimens ranged from seawater and sediments to penguin droppings and marine organisms.

Gathering the samples was not an easy task. The scientists worked in temperatures as low as –25 degrees Celsius, braving winds of up to 160 kilometres per hour. While these conditions were incredibly challenging for the researchers, the wildlife around them seemed unfazed.

"One of our stops was Esperanza base, in the middle of a penguin colony," Oberhaensli said. "You open the door, and there are penguins looking at you. An ice storm made it almost impossible for us to move around there, but the penguins just came and went quietly, hunting for fish and feeding their chicks. It was incredible."



Research and capacity building for one of the world's most pressing problems

The venture to Antarctica was part of the IAEA's flagship Nuclear Technology for Controlling Plastic Pollution (NUTEC Plastics) initiative. Marine monitoring is a central pillar of NUTEC Plastics because large volumes of plastic waste end up in the ocean. NUTEC Plastics also works with countries to tackle the problem at source by developing innovative techniques to improve plastic recycling.

NUTEC Plastics supports marine research by providing marine sampling equipment to laboratories around the world and training scientists to use it. The initiative fosters the sharing of data on ocean microplastic pollution, as well as best practices in data collection and analysis using nuclear and isotopic techniques.

Organized as part of a technical cooperation project in Argentina, the Antarctica expedition was also a capacity building mission. The IAEA scientists trained Argentine researchers, sharing nuclear and isotopic techniques for microplastic analysis. "One of our key goals is knowledge transfer," emphasized Alonso, noting that research teams from Argentina and other countries will in future be provided with the same advanced equipment through the NUTEC Plastics initiative.

Following a 2022 visit by IAEA Director General Rafael Mariano Grossi, the IAEA has been supporting scientists at the Argentine Antarctic Institute in their ongoing study of marine environment pollution through staff training, the provision of analytical equipment, and a technical cooperation fellowship at the IAEA Marine Environment Laboratories.

"The IAEA's support is very important for Argentina's scientific development," said Frank Sznaider of Argentina's National Scientific and Technical Research Council. "Their approach — analysing many and varied samples using their nuclear-derived technology that is not currently widely available in Argentina — sheds more light on the impact of microplastics on the marine environment surrounding our country and our Antarctic bases." Sznaider hopes this joint research marks the beginning of an ongoing collaboration that will enhance Argentina's scientific capabilities. "Undoubtedly, the more data we have worldwide — especially in remote and sensitive areas such as the Antarctic seas — the more effectively we can manage and address this kind of pollution."

Nuclear technologies play a crucial role in microplastics research. Analysing particles of this size is technically challenging. Using techniques like vibrational spectroscopy, scientists can characterize different types of plastic and potentially trace their origins. This information is critical for developing targeted pollution mitigation strategies.

IAEA NUTEC PLASTICS

fosters the sharing of data on ocean microplastic pollution, as well as best practices in data collection and analysis using nuclear and isotopic techniques.

scan to learn more

IAEA scientists expose plastic to Antarctic seawater to assess degradation rates and patterns.

(Photo: Argentine Antarctic Institute)

Metian, Oberhaensli and Alonso at Argentina's Esperanza research station.
(Photo: IAEA)

Metian and Oberhaensli collecting samples of Antarctic beach sand near Argentina's Carlini research station.
(Photo: Argentine Antarctic Institute)

"By identifying the polymer types, we have pointers to the source of the pollution," Oberhaensli explained. "For example, polyethylene terephthalate, or PET, is commonly used for packaging such as water bottles, while polyamide might come from clothing fibres."

The IAEA researchers received strong support from Antarctica's international community of scientists. In a place where human activity is just a speck in an endless landscape of sea and ice, and where the weather can change by the hour, people draw close together and support each other.

"The mission was organized with gracious support from Argentina; we visited a Chilean base and a Uruguayan one," said Metian. "We met polar scientists from all over the world and were warmly welcomed everywhere."

Small but significant: preliminary findings

Back in Monaco, Oberhaensli, Metian and Alonso dissolved clams, fish, penguin droppings and other specimens as part of a sophisticated process, involving nuclear and radiological techniques, that does not affect microplastics. This allowed them to identify the types and origins of the microplastics they found — crucial information for developing effective policies to control pollution worldwide.

The preliminary results were alarming: every sample analysed contained microplastics, including polytetrafluoroethylene (PTFE), polyvinyl chloride (PVC), polypropylene and PET. These findings underscore the global reach of plastic pollution, even in what was once considered a pristine environment.

Perhaps most significantly, the research highlights the potential environmental risks of microplastics. Small particles of this scale can penetrate the membranes of organisms, potentially causing biological impacts that are not yet fully understood. "The extremely small size of microplastics means that they can enter an organism in ways that larger plastics cannot," observed Oberhaensli.

The data will be shared through multiple channels, including the United Nations Environment Programme and the Global Partnership on Plastic Pollution and Marine Litter. This ensures that the findings contribute to a growing global understanding of marine plastic pollution.

As the IAEA continues to expand NUTEC Plastics, this Antarctic mission represents a critical step in monitoring and addressing global plastic pollution. The research not only provides scientific insights but also serves as a powerful reminder of human impact on even the most remote parts of our planet.

(Photo: M. Metian/IAEA)

IAEA DATABASES

A wealth of nuclear knowledge at your fingertips

Data underpins the IAEA's work in areas ranging from agriculture and the environment to health and nutrition, energy, nuclear safety and security and beyond.

Below is a selection of IAEA databases that are supporting the work of decision makers, scientists and other experts around the world.

AGRICULTURE & ENVIRONMENT

GLOBAL NETWORK OF ISOTOPES IN PRECIPITATION

The Global Network of Isotopes in Precipitation (GNIP), established in 1960, provides scientists with detailed information on the origin of water samples from around the world, helping them to better understand the water cycle globally and locally. GNIP enables them to study how precipitation patterns change, how different rainfall events transfer to the groundwater system, and how changing global rainfall patterns affect local water resources. This in turn helps decision makers manage water resources more effectively.

Learn more about **GNIP**

FAO/IAEA MUTANT VARIETY DATABASE

Stronger, healthier and more resilient crops can strengthen food security and help advance development. Plant mutation breeding is an environmentally friendly process that uses radiation to speed up the natural process of spontaneous genetic variation to produce plant varieties with higher yields, shorter cultivation times and greater resistance to diseases, pests and climate change. The FAO/IAEA Mutant Variety Database documents new varieties of essential crops ranging from cotton to corn, tomatoes and soybeans, as well as over 200 others. The database currently includes more than 3400 varieties from 78 countries.

Learn more about **mutation crop breeding**

HEALTH & NUTRITION

HUMAN MILK INTAKE DATABASE

According to the World Health Organization, exclusive breastfeeding for the first six months of life offers benefits for optimal growth, development and health. The IAEA's Human Milk Intake Database contains data from studies that use a non-invasive isotopic technique to measure how much milk breastfed infants consume. By combining and harmonizing studies from all over the world, the database aims to enable researchers to uncover new insights into breastfeeding practices, helping to promote them.

Learn more

BODY COMPOSITION DATABASE

The IAEA's Body Composition Database aims to help countries devise better health policies to combat growing malnutrition and obesity challenges worldwide. It brings together data on the proportion of fat and lean tissue in the human body, collected from all regions and all age groups using nuclear techniques. These data will help advance understanding of malnutrition, obesity and the factors affecting body composition, and support the design of nutrition strategies for prevention and management.

Learn more

DOUBLY LABELLED WATER DATABASE

Energy expenditure measurements are used to determine the number of calories a person needs to function. The IAEA's Doubly Labelled Water Database collects these measurements from studies conducted around the world that use the doubly labelled water isotope technique, a non-invasive method that is the gold standard for measuring energy expenditure in normal, everyday settings. A useful resource for researchers and policymakers alike, the database has helped redefine our understanding of human energy metabolism and is enabling nutrition experts to re-evaluate human energy requirements.

Learn more

IAEA MEDICAL IMAGING AND NUCLEAR MEDICINE GLOBAL RESOURCES DATABASE

Medical imaging and nuclear medicine are crucial to diagnosing and treating cancer, heart conditions, infectious diseases such as tuberculosis and more. However, vast gaps in access to these crucial tools still exist. The IMAGINE database provides detailed information on medical imaging and nuclear medicine resources in over 190 countries and territories. This data is essential for strategic planning to improve health outcomes, particularly in low and middle income countries.

Learn more about **IMAGINE** and other human health databases

A WORLD OF **NUCLEAR KNOWLEDGE**

The International Nuclear Information System (INIS) hosts one of the world's largest collections of published information on the safe, secure and peaceful uses of nuclear science and technology.

INIS contains bibliographic references and full-text knowledge products for conventional and non-conventional literature, including scientific and technical reports, conference proceedings, patents and theses. It covers all areas of IAEA activities, including nuclear engineering and technology, nuclear safety and radiation protection, safeguards and non-proliferation, applications of nuclear and isotope techniques, nuclear and high energy physics, nuclear and radiation chemistry, nuclear applications in life sciences, environmental and economic aspects of nuclear and non-nuclear energy sources, as well as legal aspects.

Established in 1970, INIS is operated by the IAEA in collaboration with over 130 countries. INIS assists Member States in building and expanding their nuclear information capacities through the IAEA technical cooperation programme as well as e-learning courses and training events covering all aspects of INIS operations.

Learn more about
INIS

ENERGY

ADVANCED REACTOR INFORMATION SYSTEM

The Advanced Reactor Information System (ARIS) database provides countries with balanced, comprehensive and up-to-date information about advanced nuclear power reactor designs and concepts as well as important development trends. ARIS features power reactors of all sizes and types, including innovative reactor concepts still under development. It is a valuable resource for countries with nuclear power programmes, as well as those considering their first nuclear power plant.

Learn more about **ARIS**

RESEARCH REACTOR DATABASE

More than one third of the nuclear reactors in operation around the world are research reactors, which produce neutrons for medicine, industry and agriculture and are used in research, development, education and training. The IAEA's Research Reactor Database contains technical information on over 800 research reactors in 71 countries.

Learn more about
research reactors

WORLD DISTRIBUTION OF URANIUM AND THORIUM DEPOSITS

The World Distribution of Uranium and Thorium Deposits (UDEPO) database contains information on the geological and technical characteristics of uranium and thorium deposits throughout the world, as well as their geographical distribution. UDEPO provides insights into uranium mineralization and is also used to evaluate regional-scale resource potential and related modelling and assessment methods. Users include academic and industry researchers, policymakers and decision makers, and the general public.

Learn more about **UDEPO**

NUCLEAR SAFETY & SECURITY

RADIATION SAFETY INFORMATION MANAGEMENT SYSTEM

The IAEA's Radiation Safety Information Management System (RASIMS) gives countries a framework for collecting, viewing and analysing information on the status of their national infrastructure for radiation, transport and waste safety. It covers all aspects, including regulatory infrastructure, occupational radiation protection, radiation protection in medical exposure, public and environmental radiation protection, education and training in radiation protection and safety, and transport safety.

Learn how **RASIMS** supports safe transport of radioactive material.

IPPAS GOOD PRACTICES DATABASE

The International Physical Protection Advisory Service (IPPAS) assists countries in strengthening their national nuclear security regimes, systems and measures. It focuses on physical protection of nuclear and other radioactive material, associated facilities and activities. Drawing on the experience of more than 100 IPPAS missions over the past 30 years, the IPPAS Good Practices Database currently includes over 530 good practices for securing these materials, facilities and activities.

Learn about **IPPAS**

INCIDENT REPORTING SYSTEMS FOR NUCLEAR INSTALLATIONS

The IAEA administers three separate incident reporting systems for nuclear installations to help improve the safety at nuclear power plants, fuel cycle facilities and research reactors. The reporting systems collect, analyse, maintain and disseminate reports from participating countries on safety-related events at nuclear installations. They enable contributors to share operating experience and lessons learned with the international nuclear community so that other users can use this information to improve safety at their nuclear installations.

Learn about the **Incident Reporting Systems** from a user's perspective

Understanding radioactive discharges

Scientists use IAEA database to improve environmental monitoring

By Jonah Helwig

Radionuclides are unstable chemical elements that emit radiation as they break down and become more stable. They occur on a daily basis in nature and can also be created artificially.

During normal operation of a nuclear power plant, very low amounts of radionuclides are discharged into the atmosphere and surface water bodies such as rivers, lakes and oceans. The radiation that will be discharged is carefully determined before operations even begin. The type and quantity of radionuclides that nuclear facilities discharge depend on the reactor's design, and operators are required to perform radiological environmental impact assessments to demonstrate that the discharges will result in a dose below the internationally accepted safety limit of 1 millisievert (mSv) per person per year, as laid out in the IAEA's safety standards.

In reality, the radiation exposure to the public from nuclear plant discharges is far below this level. Someone living near a nuclear power plant is exposed on average to an annual effective dose of about 0.0001 mSv — a tiny fraction of the accepted safety limit. This is equivalent to the radiation a person receives from eating a banana and is well below the level of exposure from a ten-hour aeroplane flight. Nonetheless, operators and regulators perform monitoring near nuclear power plants to demonstrate that discharges remain below the safe limit.

A new study by a team of Spanish researchers published in the science, medicine and engineering journal *Heliyon* aimed to provide monitoring organizations and regulators with information on best practices for monitoring water near nuclear power plants, focusing on radionuclides in groundwater destined for uses other than human consumption, for example irrigation.

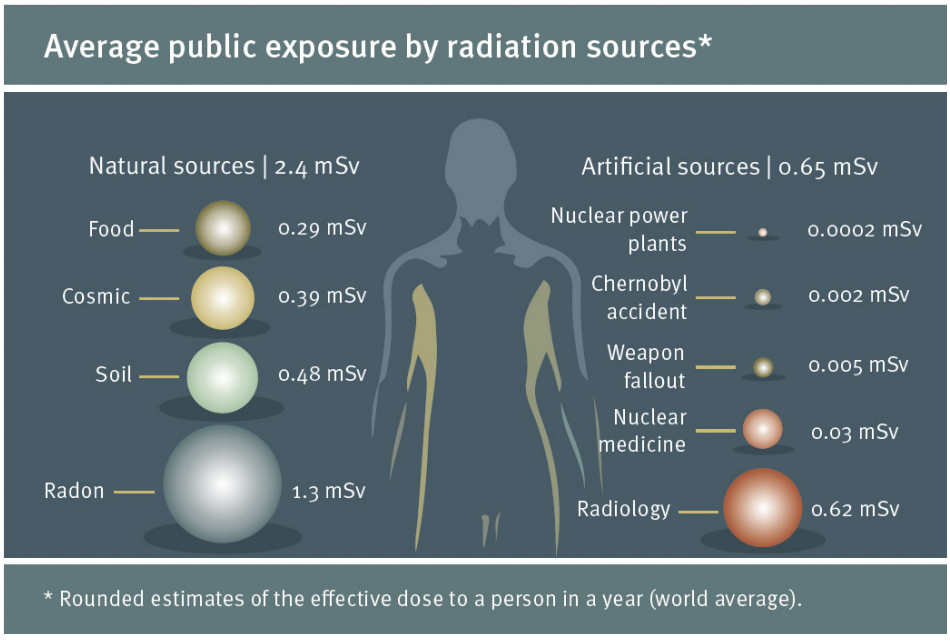
The researchers sought to identify common radionuclides discharged from nuclear power plants and to recommend practical testing methods that laboratories can use to screen for those radionuclides. Because they required substantial data on environmental discharges, they relied on the IAEA's Discharges of Radionuclides to the Atmosphere and Aquatic Environment (DIRATA) database, which includes data from nuclear facilities in all regions.

"We chose DIRATA because the data are up-to-date and reliable," said the study's lead researcher, Susana Petisco-Ferrero, Assistant Professor of Energy Engineering at the University of the Basque Country. "It also has data from around the world, which allowed us to create a more representative study by incorporating data from North and South America as well as from the European Union."

Once a year, 25 countries (73 per cent of countries with nuclear power plants) voluntarily submit discharge data, which is accessible via the DIRATA portal. DIRATA offers participating countries a platform to facilitate transparent reporting of the very low amounts of radionuclides discharged during normal operation of nuclear facilities and activities. It also includes historical

DIRATA
includes data from nuclear facilities in all regions

To learn more scan here

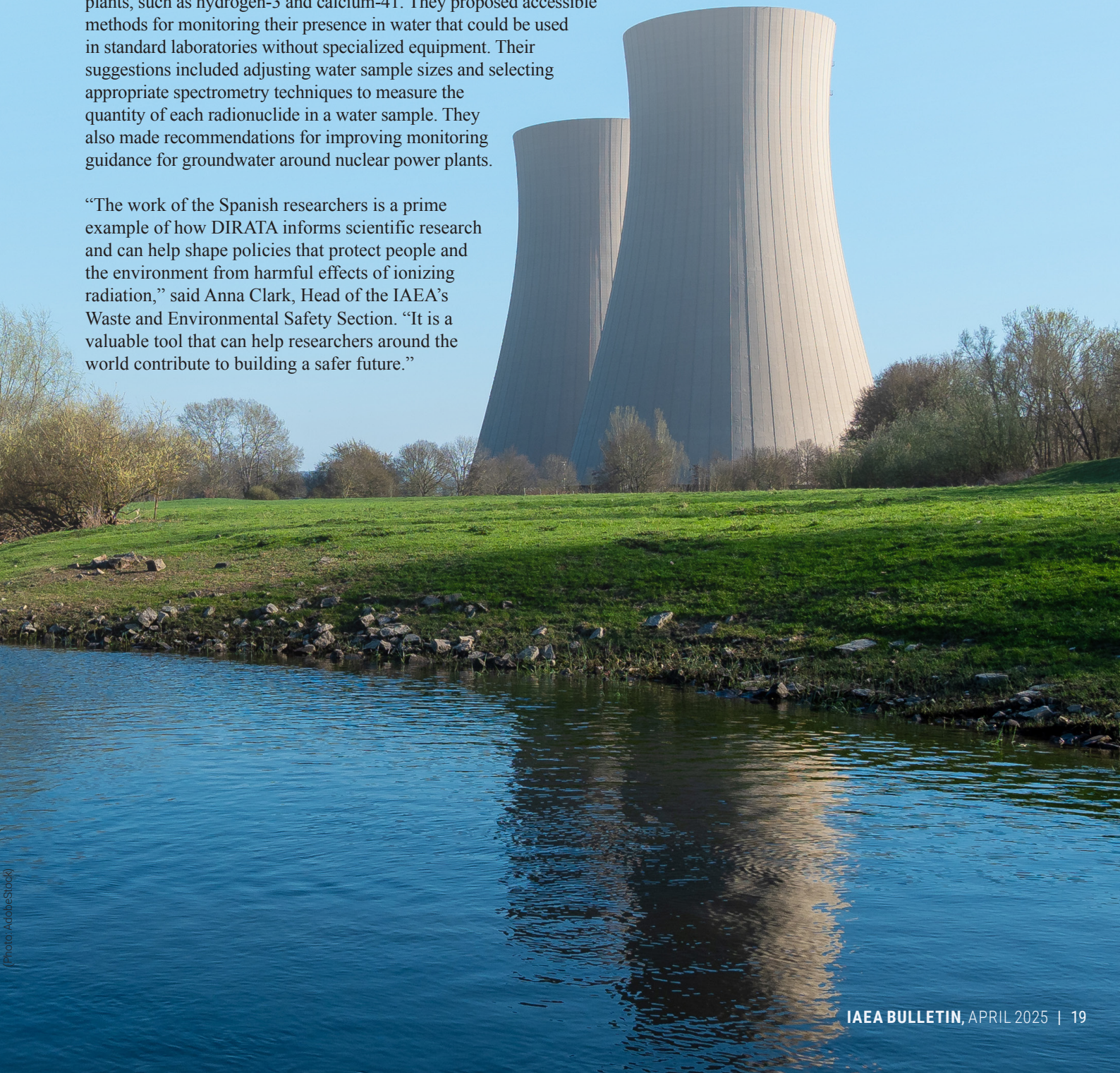


(Chart: United Nations Environment Programme)

discharge records collected by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the European Commission, and other international and national organizations. The data in DIRATA can be used by regulatory bodies, nuclear operators and researchers to track trends and improve monitoring programmes.

Using the DIRATA database, the Spanish researchers were able to compile a comprehensive list of common radionuclides discharged from nuclear power plants, such as hydrogen-3 and calcium-41. They proposed accessible methods for monitoring their presence in water that could be used in standard laboratories without specialized equipment. Their suggestions included adjusting water sample sizes and selecting appropriate spectrometry techniques to measure the quantity of each radionuclide in a water sample. They also made recommendations for improving monitoring guidance for groundwater around nuclear power plants.

“The work of the Spanish researchers is a prime example of how DIRATA informs scientific research and can help shape policies that protect people and the environment from harmful effects of ionizing radiation,” said Anna Clark, Head of the IAEA’s Waste and Environmental Safety Section. “It is a valuable tool that can help researchers around the world contribute to building a safer future.”



(Photo: AdobeStock)

Unlocking clean energy

Advancing fusion research and development

By Mary Albon

Fusion offers a promising clean energy solution since the process is carbon free, inherently safe, and produces continuous, unlimited fuel. The IAEA has supported fusion research and development from the beginning, organizing the first international conference on fusion energy in 1961. More recently, breakthroughs in fusion research have accelerated development in both the public and private sectors. Building on this progress, the IAEA fosters international collaboration and coordination to bridge gaps in the physics, technology and regulation of fusion. This includes collecting and sharing data to support all phases of fusion research, from the science of the fusion process to plant design and operation.

"Fusion technology has the potential to transform global energy production," said Aline des Cloizeaux, Director of the IAEA's Division of Nuclear Power. "Fusion energy together with the deployment of advanced nuclear fission will ensure a sustainable clean energy transition."

Data for fusion research and development

Fusion is fuelled by light isotopes, which form a plasma — a hot, charged gas with unique properties distinct from solids, liquids and gases. **CollisionDB**, an IAEA database for atomic and molecular processes, supports advances in plasma operational scenarios and diagnostics, increasing understanding of plasma collisional processes.

Other IAEA databases contribute to the operation and optimization of experimental devices and future fusion plants. The **plasma-wall interaction database** (pwiDB) contains data on interactions with the surface of the inner wall, while **CascadesDB** and **DeFecTDB** collect data on processes within the wall. The **Fusion Evaluated Nuclear Data Library** (FENDL) holds essential nuclear reaction data for neutronics concerning plasma and materials, which are crucial for safety and waste assessments.

Advancing toward net fusion energy

Scientists and engineers around the world continue to develop and test new materials and design new technologies to produce net fusion energy. While experiments routinely achieve conditions very close to those required for a fusion energy system, improvements are still needed to maintain the reaction and produce energy in a sustained manner. Public and private fusion organizations are rapidly making advances toward this goal.

The IAEA's **Fusion Device Information System** (FusDIS) provides a global overview and technical data and statistics on public and private fusion devices in operation, under construction or in planning. It offers useful guidance for fusion energy strategies and decision making, as well as public-private collaboration, and it is a valuable tool for identifying research trends. FusDIS can be found on the **IAEA Fusion Portal**, a resource hub for information on the Agency's fusion activities.

The IAEA is also developing **FUSE**, on the Agency's CONNECT platform, to assist developers of fusion technology during the design, manufacturing and construction of fusion plants. It will include a database on fusion codes and standards, as well as a fusion technologies and fuel cycles database with information and specific parameters for each device in development. FUSE will raise awareness of the latest developments, such as spin-off technologies, in the rapidly evolving fusion sector.

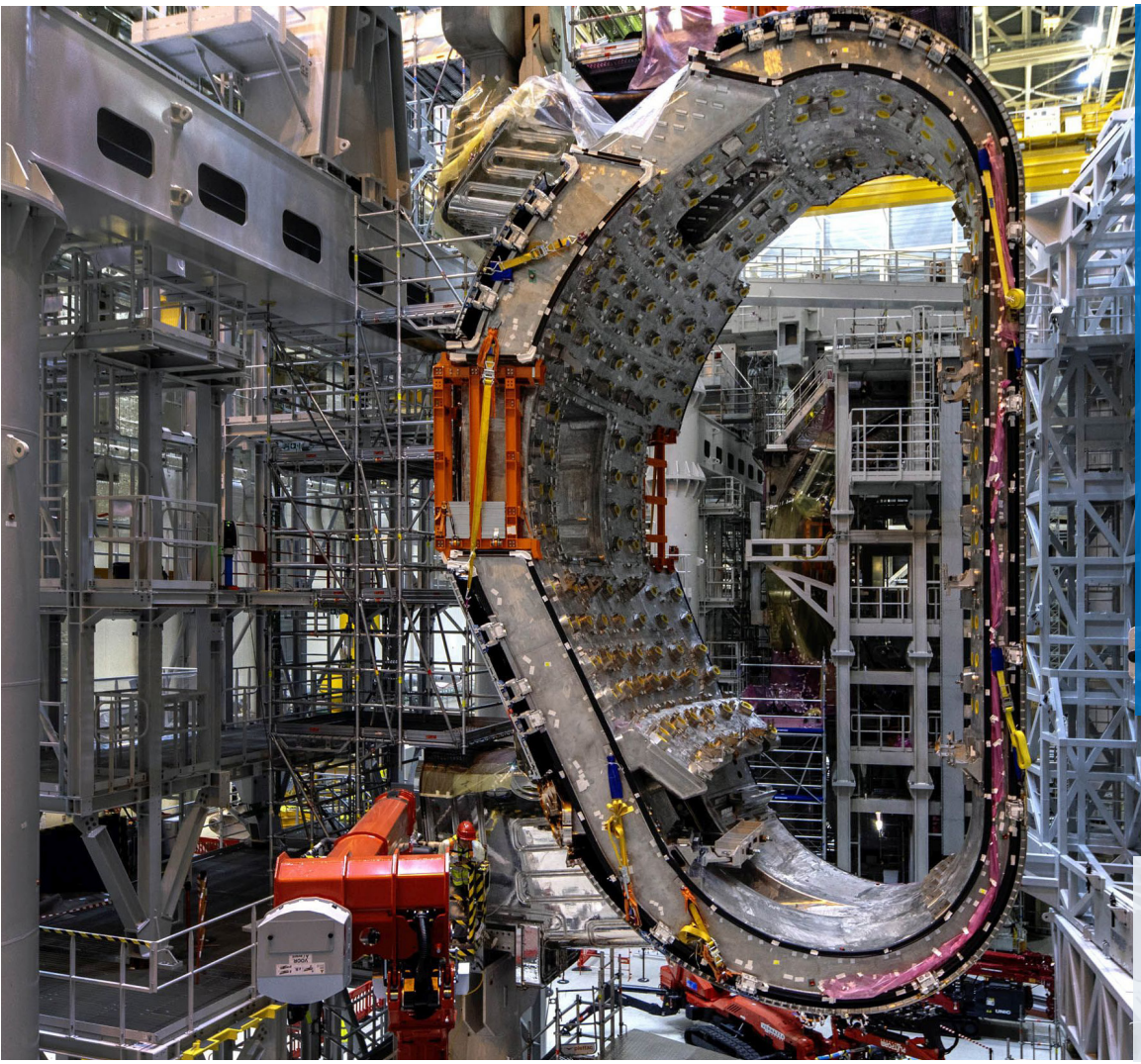
Unlocking fusion's potential with artificial intelligence

"Artificial intelligence is a new key for unlocking the full potential of fusion. It offers potentially significant benefits for managing the entire engineering process of fusion devices as well as analysing the huge amount of scientific and engineering data such facilities will produce," said Alain Becoulet,

IAEA DATABASES
for fusion research and development

Scan to learn more

- **Collision**DB
- **Cascades**DB
- **DeFecT**DB
- **pwi**DB
- **FENDL**
- **FusDIS**
- **IAEA Fusion Portal**
- **AI for Fusion** (AI4F)



WHAT IS **FUSION ENERGY?**

Fusion is the process by which two light atomic nuclei combine to form a single heavier one while releasing massive amounts of energy. The sun and all other stars are powered by a similar process.

On Earth, temperatures of over 100 million degrees Celsius are needed to achieve fusion, and pressure and magnetic forces must be regulated to maintain the process long enough to produce net energy.

(Photo: ITER Organization)

Construction continues in 2025 on the ITER fusion device, which is designed to prove that fusion can be a large-scale, carbon-free source of energy.

Deputy Director General and Chief Scientist at the ITER Organization. "To achieve this potential, we need dedicated platforms for managing fusion data in the same cooperative spirit that has been driving fusion research for decades. This is crucial to accelerating the deployment of fusion energy."

An IAEA coordinated research project, **AI for Fusion** (AI4F), aims to do just that. AI4F is fostering innovation and collaboration to drive fusion breakthroughs by leveraging artificial intelligence (AI), machine learning and big data technologies. Twenty-four institutions in 11 countries on 4 continents are participating. "AI and machine learning can accelerate fusion research on the path towards a first-of-its-kind pilot plant," said Cristina Rea, Principal Research Scientist and Group Leader at the Massachusetts Institute of Technology's Plasma Science and Fusion Center. "The IAEA has become a steward for this mission," she said.

"Harnessing fusion energy represents the pinnacle of science and engineering achievement," said Tzanka Kokalova-Wheldon, Director of the IAEA's Division of Physical and Chemical Sciences. "The IAEA is providing essential data, leveraging cutting-edge technologies and fostering partnerships to help develop and scale up the ultimate clean energy source."

Powering progress with data

The IAEA Power Reactor Information System

By Marta Gospodarczyk

PRIS
is an invaluable tool for nuclear operating and decommissioning countries, nuclear newcomers and international and non-governmental organizations.

Scan to learn more

For 55 years, the IAEA's Power Reactor Information System (PRIS) has been collecting, managing and disseminating official data and statistics on nuclear power reactors to ensure information transparency, reliability and accessibility for member countries and industry stakeholders. Its standardized and continuous data collection direct from official sources in 38 countries makes PRIS an invaluable tool for nuclear operating and decommissioning countries, as well as nuclear newcomers and international and non-governmental organizations.

PRIS data are used to support a variety of critical operational tasks as well as periodic reviews vital for safe, secure and reliable operation. For example, Teollisuuden Voima Oyj (TVO), an operator in Finland, uses PRIS reports to evaluate its reactors' power history and operating experience, and prepares reports based on the findings to help optimize reactor efficiency.

The country nuclear power profiles (CNPPs), created in 2010 and completely revised in 2023, complement PRIS by providing comprehensive overviews of a country's nuclear power infrastructure, policies and long-term development strategies.

The PRIS Statistics performance indicators system allows users to assess nuclear reactor efficiency, safety and reliability. It provides tools for comprehensive trend analyses and benchmarking, as well as statistical insights that help Member States optimize reactor performance. For instance, reports on unplanned outages help identify root causes such as equipment failures, allowing operators to learn from each other's experiences. The World Association of Nuclear Operators (WANO) uses PRIS to benchmark performance indicators and make routine comparisons with its operators' information reports, improving data quality in both PRIS and WANO's performance indicator systems.

Supporting nuclear power operations, development and transitions

"As countries increasingly turn to nuclear power to address climate change and energy security challenges, PRIS and the CNPP databases play a crucial role for our Member States in guiding their nuclear energy planning and programme monitoring," said Shin Whan Kim, Head of the IAEA's Nuclear Power Engineering Section. "They provide Member States with access to valuable lessons learned from past deployments, construction projects and operational experiences." For example, experts from Paks II. Ltd. responsible for preparatory work on new nuclear power plant units in Hungary not only report on the progress of their own construction projects but also use PRIS data on reactors under construction worldwide. By analysing reported construction progress and lessons learned from other projects, they enhance planning, learn about potential challenges and implement best practices, ultimately improving efficiency and reducing uncertainties in the construction and commissioning of new units.

"Our company uses the PRIS database as a vital tool for benchmarking and performance analysis," said Attila Hugyecz, Chief International Officer for Paks II. Ltd. "The database is an essential resource for our commitment to operational excellence and continuous improvement."

For nations with established nuclear programmes, PRIS is an essential tool for optimizing plant operations. By leveraging its performance indicators and benchmarking data, operators can learn how to improve efficiency, reduce unplanned outages and plan for future technological upgrades. China's Nuclear Power Operations Research Institute (NPRI), for example, uses PRIS to access global performance metrics, reliability trends and operational benchmarks, which help it develop and improve its own performance indicator system.

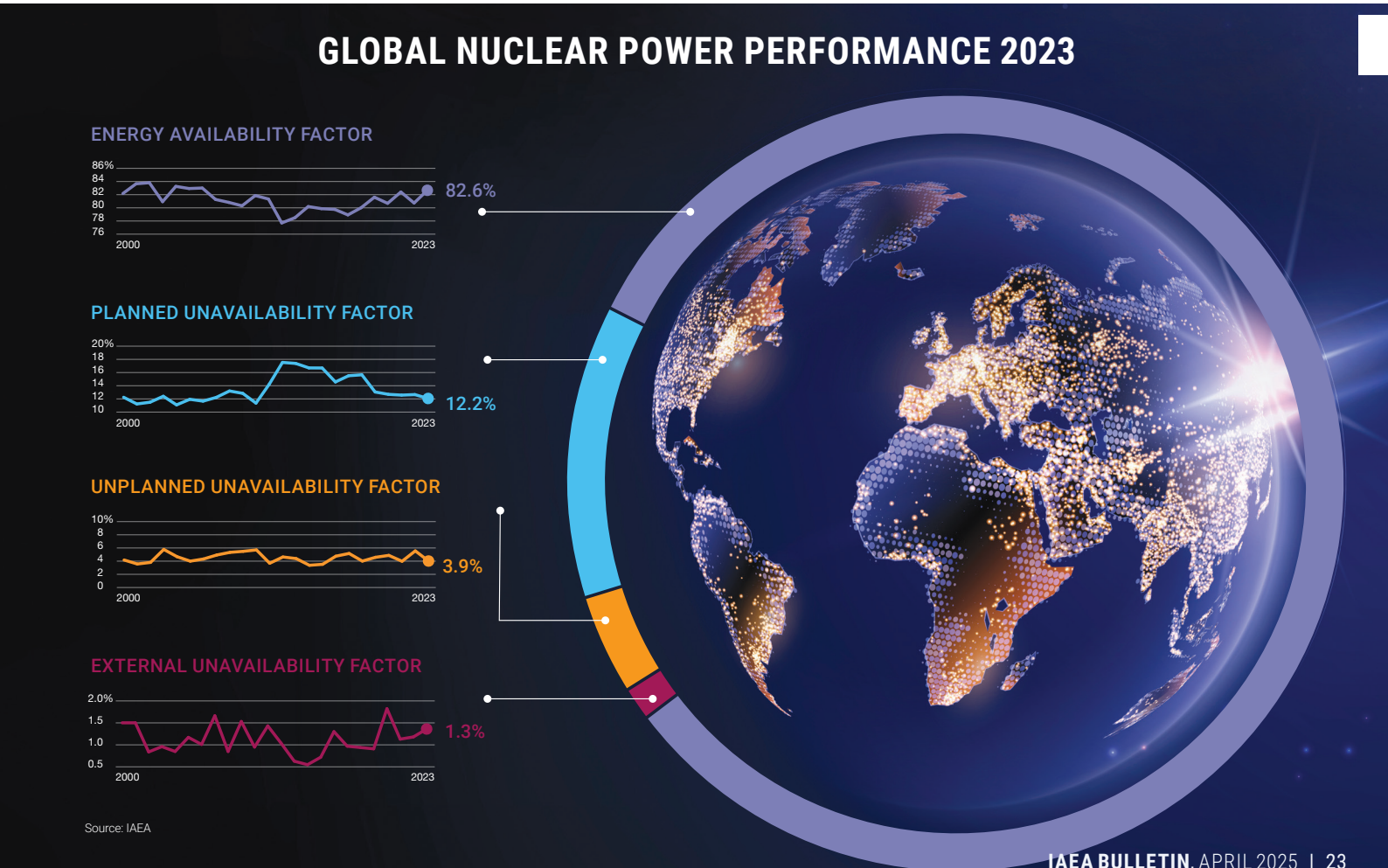
"NPRI has developed a nuclear power plant performance analysis tool platform using the PRIS database to help visualize reactor data and enhance performance," said Hongxu Lu, an engineer at NPRI. "We have also used PRIS to support our efforts to better manage our data quality and ensure the consistency of the performance analysis tool platform." As reactors age, PRIS helps with planning for long-term operations or transitioning from operation to decommissioning. Currently, 35 per cent of operational nuclear power capacity (136.4 gigawatts (electrical), 168 reactors) has been in operation for over 40 years. PRIS provides data on shutdown causes, decommissioning strategies, fuel management and project milestones, allowing countries to develop informed plans for transitioning from operation to decommissioning.

PRIS data is also used by numerous non-governmental organizations and international organizations to track reactor performance, construction and decommissioning status as well as global nuclear operating capacity and trends. For example, the Intergovernmental Panel on Climate Change cited PRIS data in a 2022 report on climate change mitigation to support its findings that nuclear generation has increased in recent years, with nuclear power identified as an established technology that can help reduce emissions. The World Nuclear Association uses the PRIS database to populate its reactor dashboards and information library, and includes it in its publications on reactor performance, the nuclear supply chain and nuclear fuel.

The future of PRIS

As the IAEA continues to enhance PRIS, including with the most advanced data exploration and visualization tools, users will be able to conduct more in-depth analyses. By leveraging state-of-the-art analytics technologies, PRIS can further support countries in making informed decisions on nuclear power development, operational safety and efficiency, long-term operations and decommissioning strategies.

By continuously evolving and expanding its data collection capabilities, PRIS ensures that Member States have access to the critical information they need to ensure safe and efficient nuclear power plant operations and support nuclear power programme development.



Planning for the clean energy transition

Modelling Estonia's path to a sustainable future

By Matt Fisher

IAEA
ATOMS 4 NET ZERO

helps countries to make science based decisions to harness the full potential of nuclear energy.

Scan to learn more

Estonia can meet its carbon emission reduction targets with a diversified energy mix that includes nuclear power as a key component, according to a study conducted by researchers at the University of Tartu. The analysis, performed with an IAEA energy modelling tool, has shed light on what the Baltic State's future clean energy system could look like — and the cost of the different pathways to achieve it. The IAEA supported the project with capacity building and technical guidance through its Atoms4NetZero initiative, as Estonia looks to eliminate its reliance on shale oil by 2050.

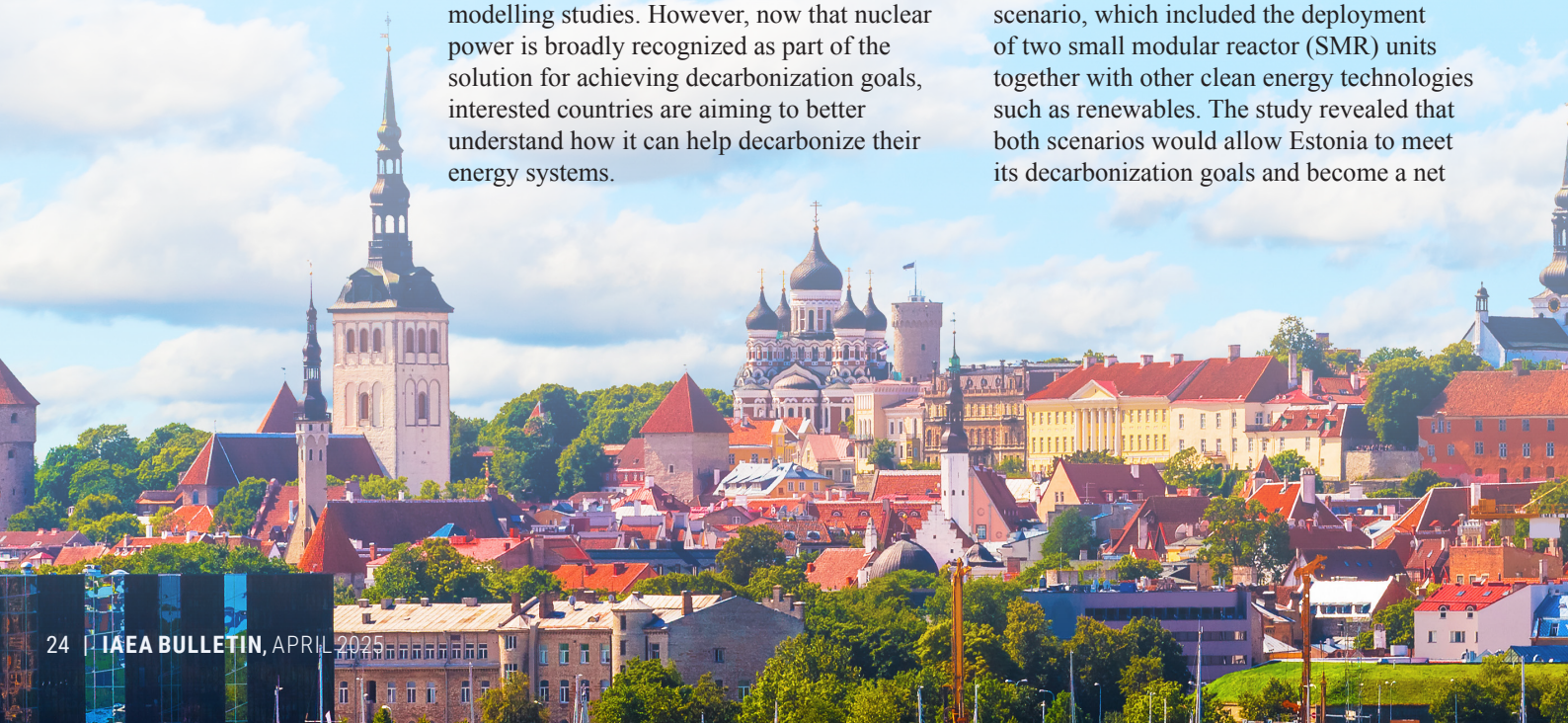
At the end of 2023, Estonia's Nuclear Energy Working Group submitted a report detailing how, with sufficient planning, funding and public approval, nuclear power could contribute to achieving Estonia's goals for climate change mitigation, energy security and economic growth. In June 2024, after reviewing the report, Estonia's parliament endorsed preparations for introducing nuclear power and agreed to take steps to establish a legal framework governing its use.

Atoms4NetZero helps countries use a robust suite of analytical tools to consider the full potential of nuclear power in a range of energy planning scenarios. Until recently, nuclear power's role in achieving climate change mitigation goals had not been reported extensively in published energy modelling studies. However, now that nuclear power is broadly recognized as part of the solution for achieving decarbonization goals, interested countries are aiming to better understand how it can help decarbonize their energy systems.

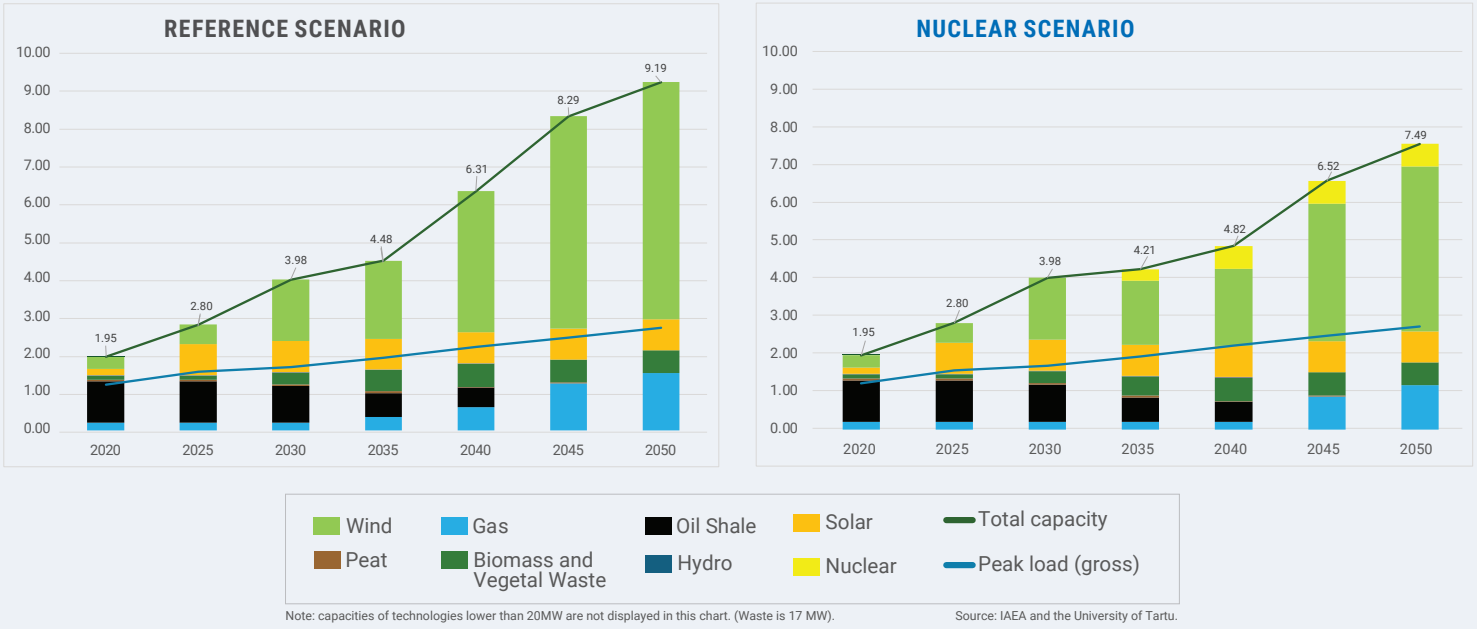
The tool used in this study, the Model for Energy Supply Strategy Alternatives and their General Environmental Impact (MESSAGE), is designed for medium to long term energy system planning and can model the full range of thermal generation technologies together with renewable energy and carbon capture and storage, as well as other technologies. MESSAGE uses an algorithm to show how a given objective can be achieved at minimal cost. Estonia's study incorporated costs associated with investment, operation, fuel, energy imports and carbon constraints, providing a holistic view of the energy system.

"This study shows that if the nuclear industry demonstrates that investment costs and construction schedules can be kept within the projected range, nuclear power is a competitive option for Estonia," said Mario Tot, an IAEA energy systems analyst. "Assuming that Estonia proceeds on the path to decarbonization and takes the scope of our analysis into account, this study illustrates how, over the long term, nuclear can provide similar outcomes to renewable sources."

The study, which used both open-source data and data from Estonian Government publications, focused on two power supply scenarios: a 'reference' scenario, based solely on expansion of the renewable energy sources, including wind and biomass, currently used in Estonia; and a 'nuclear' scenario, which included the deployment of two small modular reactor (SMR) units together with other clean energy technologies such as renewables. The study revealed that both scenarios would allow Estonia to meet its decarbonization goals and become a net



Installed capacities by energy source, GW



Note: capacities of technologies lower than 20MW are not displayed in this chart. (Waste is 17 MW). Source: IAEA and the University of Tartu.

energy exporter after 2040. Wind capacity, owing to its cost effectiveness, was identified as the largest component of Estonia's future clean energy mix in both scenarios.

"The support and flexibility of the IAEA experts was invaluable in accomplishing the study aims in a realistic timeframe. We appreciated the opportunity to interact regularly with IAEA experts, permitting us to quickly advance our modelling capability and benefit from leading know-how in the area," said Alan Tkaczyk, an Associate Professor at the University of Tartu who led the Estonian modelling team. "We shared our model results with relevant Estonian ministry colleagues who were eager to examine our findings at this important time, as the addition of nuclear power is publicly debated in Estonia."

The analysis showed that the nuclear scenario, with an assumed investment cost of €6000 per kilowatt for SMRs, would only cost 1.3 per cent more than the reference scenario. However, fully factoring in the cost of upgrades to Estonia's electrical grid and storage capacities, which would be necessary for a large expansion of wind power, would provide a more refined analysis that better supports the cost competitiveness of nuclear power. An energy system using nuclear power, which can provide baseload energy to the grid 24/7 in all weather conditions, could be more resilient and secure than one built according to the reference scenario with very high shares of wind power. Additional studies are needed to fully assess grid expenses and other related costs for alternative strategies.

"Our role is to help researchers apply tools to develop energy plans aligned with their clean energy goals. For countries interested in nuclear power, ensuring that it is properly accounted for in these studies is crucial," said Tot. "Building the clean energy infrastructure of tomorrow requires meticulous planning today."

Tallinn, Estonia. (Photo: AdobeStock)

Data for nuclear security

The IAEA Incident and Trafficking Database

By Vasiliki Tafili

In preparation for hosting the UEFA European Football Championship EURO 2024, Germany relied on an IAEA threat assessment analysis based on data from the Incident and Trafficking Database.

With 24 football teams competing in stadiums in 10 German cities and millions of spectators in the stands, last summer's UEFA European Football Championship EURO 2024 was an unforgettable experience. However, the event also posed a serious security challenge. By the time Germany's national football team was competing on the field, another German team comprising specialists from the country's security authorities had been working together for months to prepare for potential threats that could jeopardize the security of this major sporting event. For Germany's security authorities, the month-long EURO 2024 was the arena in which their plans and readiness would ultimately be tested.

A key element of the German security plan for UEFA EURO 2024 was the deployment of radiation detection capabilities. Since Germany had already benefited from IAEA support for nuclear security measures when the country hosted the 2006 FIFA World Cup, it again turned to the IAEA for help with UEFA EURO 2024.

To assist Germany's threat assessment efforts, the IAEA compiled information from the highly confidential Incident and Trafficking Database (ITDB) on reported incidents of trafficking and other unauthorized activities involving nuclear and other radioactive material, and provided a tailored analysis of nuclear security threats, trends and patterns in Germany and neighbouring countries.

According to Helge Kröger, Section Head for Safety and Security of Radiation Sources in Germany's Federal Office for Radiation Protection and the national ITDB Point of Contact, the report provided valuable information on the detection capabilities needed to protect the football venues, helping to ensure the success of Germany's nuclear security plan for the championship. "The report was handed over to the police as well as all the relevant regional radiation protection authorities to consider in their own preparations for EURO 2024," he said.

"Nuclear security threat assessment is an essential element of security plans for large-scale events like EURO 2024," said Elena Buglova, Director of the IAEA Division of Nuclear Security. "The assistance offered to Germany shows how the ITDB can help countries understand the risks posed by nuclear and other radioactive material outside of regulatory control."

Maintained by the IAEA, the ITDB analyses reported incidents to identify trends in nuclear security. Since its establishment in 1995, the database has become a robust

mechanism for participating countries — of which there are currently 145 — and relevant international organizations such as the International Criminal Police Organization (INTERPOL).

Between 1993 and 2024, 125 countries reported 4390 incidents to the ITDB. Approximately 8 per cent of the reported incidents were confirmed as being related to illicit trafficking or malicious use of nuclear or other radioactive material.

Around 59 per cent of the total number of reported incidents involved radioactive sources used in medical and industrial applications, while 14 per cent involved nuclear material such as uranium and plutonium. The remaining 27 per cent involved contaminated items and non-radioactive material involved in scams or fraud. Although the number of attempted scams involving non-nuclear material falsely claimed to be nuclear or radioactive remains low, their frequency has been rising.

The overall number of reported incidents involving nuclear material has declined over the years. At the same time, reports of radioactive sources ending up in the scrap metal industry have risen, underscoring the need for enhanced regulatory control over the use, storage, transport and disposal of such sources. Transport vulnerabilities stand out as a persistent challenge, with over half of reported thefts occurring during authorized transport.

"As the Incident and Trafficking Database enters its fourth decade," said Buglova, "its contribution to global nuclear security is broadly acknowledged. The ITDB is a practical tool, alerting and helping participating countries to make informed decisions, especially ahead of major public events. International cooperation and information sharing are at the heart of the ITDB, and we encourage more countries to join it."

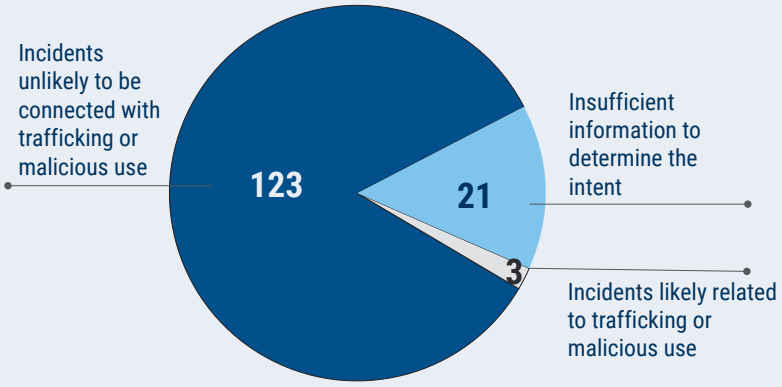
(Photo: AdobeStock)

INCIDENT AND TRAFFICKING DATABASE

In 2024

147

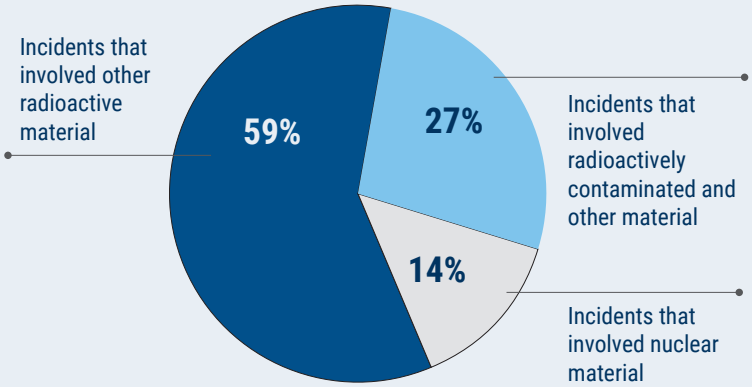
incidents of illegal or unauthorized activities involving radioactive material out of regulatory control were reported by 32 countries in line with historical averages.



Since 1993

4390

incidents have been reported



To learn more about the **Incident and Trafficking Database** scan here

A day in the life of
an IAEA nuclear trade analyst

By Haley Mead

Here's a glimpse into the average working day of an IAEA nuclear trade analyst.

MORNING

Although no day looks the same, Malin Ardhammar, an IAEA Senior Safeguards Analyst specializing in nuclear trade, often starts the day with a fundamental question: has a country traded any goods that are relevant to safeguards? She settles down at her desk with a coffee and sets about answering this question, collecting information from various sources on the nuclear industry and nuclear-relevant trade. Sources include the information declared by a State — as required under its safeguards agreement and, if applicable, additional protocol — as well as information from IAEA technical cooperation activities, industry websites and trade databases.

"We analyse international trade to assess the consistency between State-declared nuclear activities and transfers of nuclear materials and relevant commodities against public trade records," said Malin. "Our goal is to identify important outliers so that we can ask the necessary questions, clarify and support the drawing of sound safeguards conclusions."

Trade records, such as those from a country's statistics office or international trade databases such as the United Nations Comtrade database, can point to potential indicators of undeclared nuclear-related activities or transfers. Some nuclear-related items are subject to regular monitoring, such as various forms of uranium and nuclear reactor parts. Other items are investigated on a case-by-case basis, for example potentially safeguards relevant products such as mass spectrometers, lasers, pressure transducers and carbon fibre.

Once Malin has collected what she needs from each source, she can conduct a comparative analysis to check the consistency of all the available information.

SAFEGUARDS RELEVANT INFORMATION IN NUCLEAR TRADE

The IAEA has a mandate to verify the peaceful use of nuclear material and technology in the 191 States with which it has a safeguards agreement in force. To draw soundly based safeguards conclusions, the Agency employs a multifaceted approach to nuclear verification, combining in-field activities with the analysis of safeguards relevant information provided by countries and collected from other sources.

One of the ways in which the IAEA validates that State reports of nuclear material are correct and complete is through nuclear trade analysis. To perform this task, the IAEA relies on a team of safeguards analysts to evaluate the information it receives, generates and collects.

Nuclear trade analysts work in close collaboration with safeguards inspectors and other safeguards analysts. They also garner information from other IAEA departments, such as the Department of Technical Cooperation, about the Agency's wider work with States.

IAEA nuclear trade analyst Malin Ardhammar at work.

AFTERNOON

After lunch, Malin evaluates all the available information to identify potential outliers that may require further investigation. She will typically check the following elements in declared and trade-related information for consistency:

- quantities and types of nuclear materials and equipment transferred;
- dates and locations of transactions;
- names and addresses of suppliers and recipients; and
- descriptions of nuclear activities and facilities.

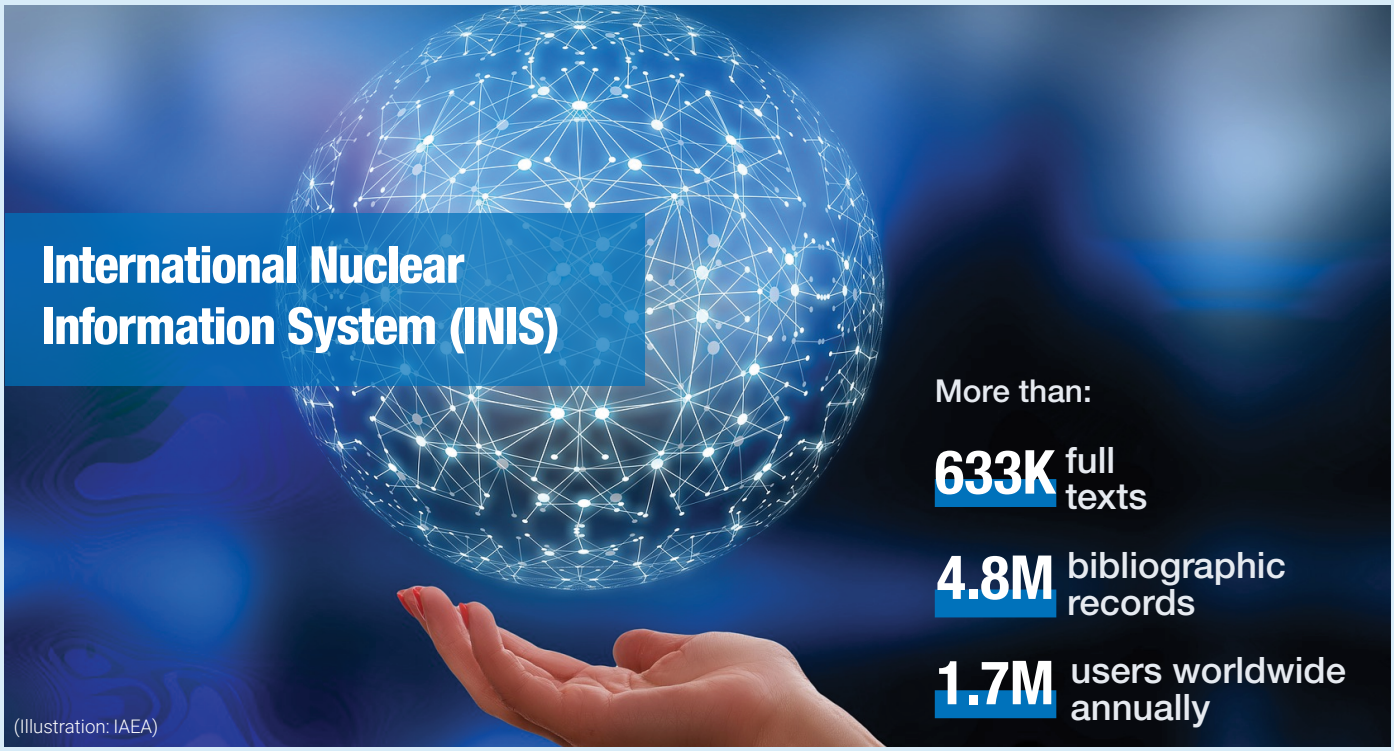
"Nuclear trade analysts have a special role because we look at additional information sources on nuclear material and activities," said Malin. "It's our job to discover which trade transactions are worth investigating further."

If any indicators of undeclared transfers are identified during the analysis, the IAEA follows up with the State concerned as appropriate. Within the scope of the safeguards agreement, this could mean submitting inquiries to the State or conducting in-field activities, such as an inspection or design information verification, aimed at resolving the issue.

(Photos: A. Barber Huescar/IAEA)

"Even though nuclear trade analysts set out to prove a negative, success in this role strengthens safeguards conclusions," Malin explained. "Through this work, I head home each day knowing that I've supported the IAEA in providing assurances to the international community that safeguarded nuclear material and technology remain in peaceful use."

Major nuclear repository adopts new fully searchable digital platform



The IAEA's International Nuclear Information System (INIS), a multimillion-strong digital library, has been further strengthened with the addition of a modern repository platform.

Founded in 1970, the INIS repository hosts a massive library of nearly five million reports, books, scientific articles, conference papers and other knowledge products covering topics in nuclear science, reactor technology, materials science, medical applications, decommissioning, and all other areas in which the IAEA is involved.

The Agency's tailored use of Invenio, an open-source platform developed by the European Organization for Nuclear Research (CERN), has enabled it to make progress in automation and accessibility and significantly increase capacity for handling new knowledge product entries in INIS. The new functionalities built with the platform allow INIS to connect with other repositories, facilitating the sharing of content and expanding the utility of all participating databases. INIS will be the first large repository to conduct full-text searches with Invenio, searching both the metadata and text of a PDF document.

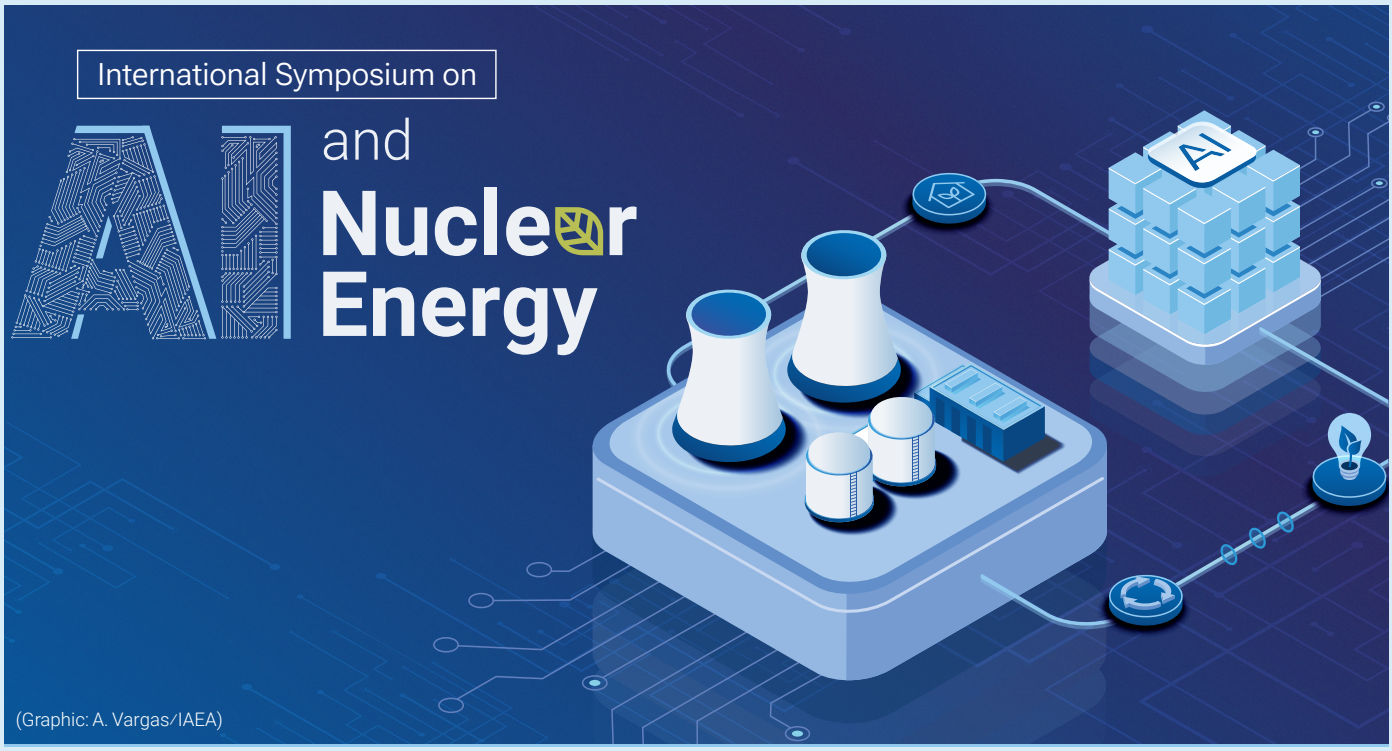
"In today's knowledge based economy, information is considered one of the most valuable resources. It is critical for research, innovation, decision making, efficiency and productivity, knowledge sharing and continuous learning," said Dibuleng Mohlakwana, Head of the IAEA's Nuclear Information Section. "This new platform will help INIS expand its role as a global player in open science, improving its capabilities as an information hub that facilitates the pursuit of nuclear science for peaceful purposes."

The landscape of scientific publishing has changed considerably in the years since INIS was founded, with an increasing emphasis on open access. Publishers are providing more information and making it freely available, while repositories such as arXiv, the Directory of Open Access Journals and PubMed have made scientific knowledge more accessible than ever before.

"One of the great things about this platform is that whatever we develop here can be shared with all the other organizations. So not only are we sharing scientific information with the world, but we're also sharing what we develop with Invenio," said Astrit Ademaj, Nuclear Systems Support Analyst and Project Manager for the implementation of Invenio.

— By Matt Fisher

IAEA to host International Symposium on AI and Nuclear Energy in December



(Graphic: A. Vargas/IAEA)

The IAEA will host the first ever **International Symposium on Artificial Intelligence and Nuclear Energy** in Vienna from 3 to 4 December 2025

The symposium will explore how nuclear energy can help meet growing electricity demand from the data centres driving artificial intelligence (AI) as well as the myriad ways in which AI can support the nuclear power industry. With AI's meteoric rise and nuclear power's potential to provide a sustainable and clean energy solution, this event is especially timely and will highlight the emerging nexus between the two industries.

"With AI becoming increasingly integrated in society and nuclear power expansion identified as vital to making reliable, clean energy abundance a reality, there is an incredible opportunity for these industries to help maximize each other's contributions," said IAEA Director General Rafael Mariano Grossi. "Nuclear power reactors can provide the reliable, clean electricity needed for the sustainability of AI and other 'big data' applications, and at the same time, AI can optimize reactor performance, advanced fuel development and other critical areas so nuclear power can reach its full potential."

The symposium will bring together relevant stakeholders from around the world, including high level representatives from the nuclear and AI sectors as well as nuclear regulators. The two-day event will feature panel discussions, exhibitions and side events delving into the dual themes of "Powering Data Centres with Nuclear Energy" and "Opportunities and Challenges for AI in the Nuclear Sector".

AI's role in numerous sectors is growing rapidly, and with this rise has come a dramatic increase in energy demand. Data centres consumed about 460 terawatt-hours (TW h) of electricity in 2022, according to the International Energy Agency, and by 2026, this consumption could exceed 1000 TW h. To help meet this demand, several major tech companies including Amazon, Google and Microsoft are looking to nuclear power, including by concluding power purchase agreements and investing in the development and deployment of small modular reactors.

The nuclear power industry is already utilizing AI tools to enhance designs, optimize construction and improve operational efficiency. Further integration of AI into these and other areas holds great potential for the industry. However, it requires careful consideration of the sector's stringent safety and security requirements.

Persons wishing to participate in the symposium will generally be registered through an IAEA Member State or be a member of an organization invited to attend.

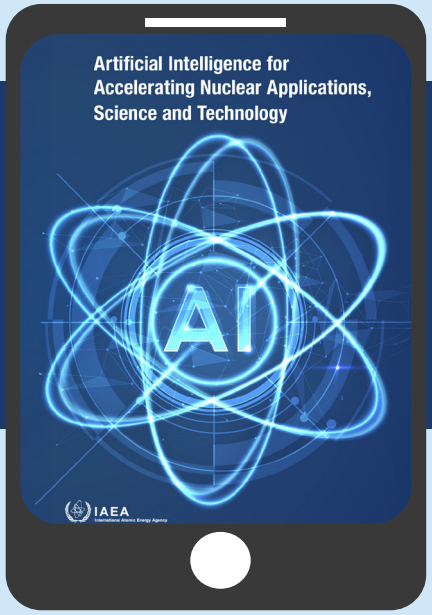
— By Matt Fisher

Did you know

that harnessing AI's capabilities in the nuclear field can help address some of today's most urgent challenges?

Scan to read

how AI is advancing the peaceful uses of nuclear sciences, technology and applications.



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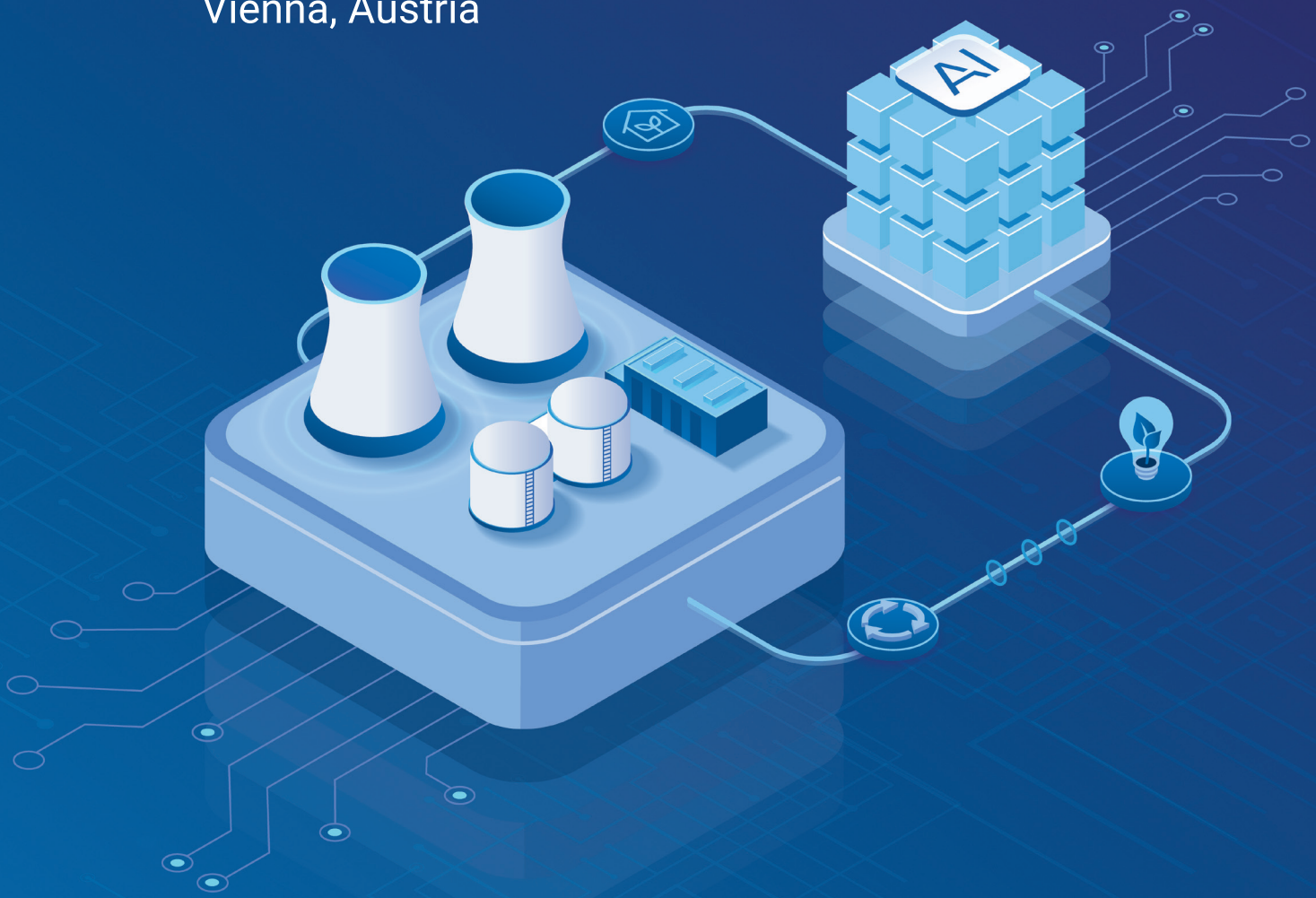

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