IAEA 60 Years Atoms for Peace and Development

IAEA Activities in Support of Research Reactors

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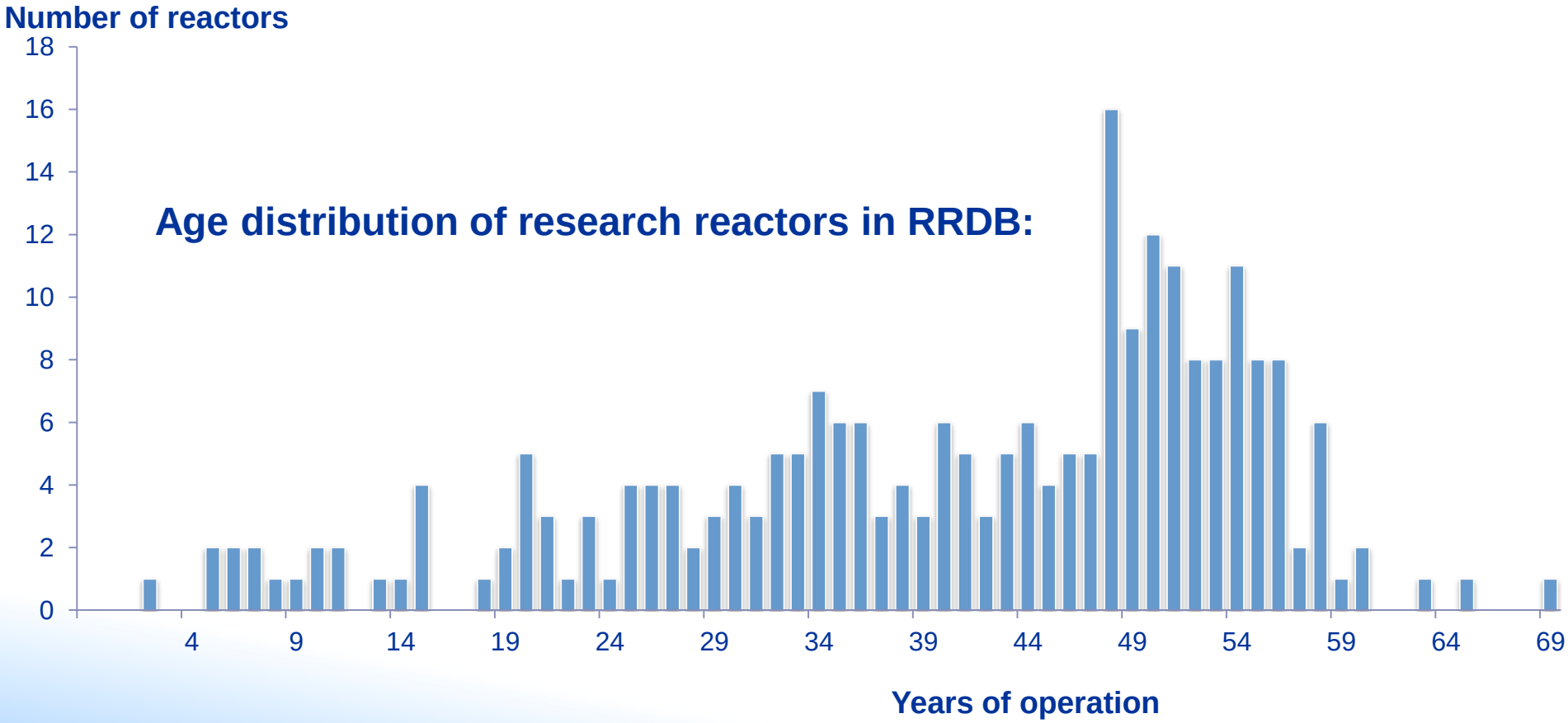
Outline

- **Ageing RRs and New Projects for RRs**
- **Organization for IAEA RR Program**
- **RR sub-programme**
  - ✓ **Utilization and Application**
  - ✓ **Infrastructure, Planning, and Capacity Building**
  - ✓ **Fuel Cycle**
  - ✓ **Operation and Maintenance**
- **IAEA Safety Program for RRs**
- **IAEA Activities for RRs**

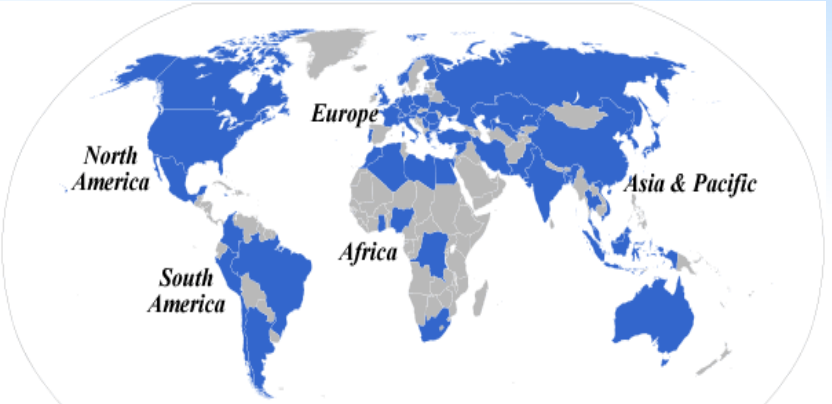
IAEA RRDB - Ageing

- **> 60% of operating RRs are over 40 years old**
- **> 50% of operating RRs are over 45 years old**
- **> 30% of operating RRs are more than 50 years old.**



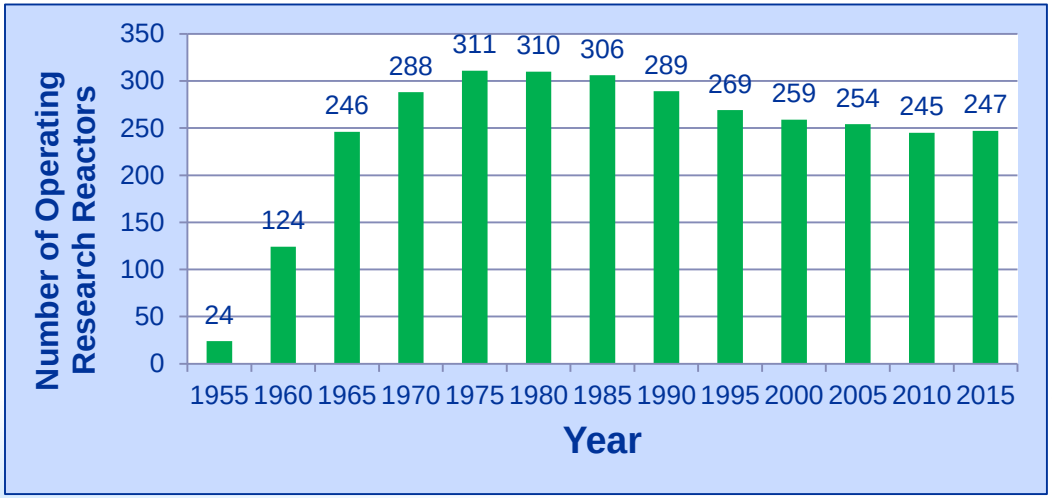
IAEA RRDB

TOTAL:	768 (2017)
Operational	216
Temp. shutdown	22
Extended shutdown	9
Under construction	8
Planned	11
Shutdown/Decommissioned	502



238 operational / Temp shutdown.

60% are over 40 years (2017).



Region	Operational RRs (2015)	Operational RRs (2017)
Africa	8	6
Americas	65	65
Asia/ Pacific	49	41
Europe	125	104

✓ **Last update in 2010-2017 by 65 Member States.**

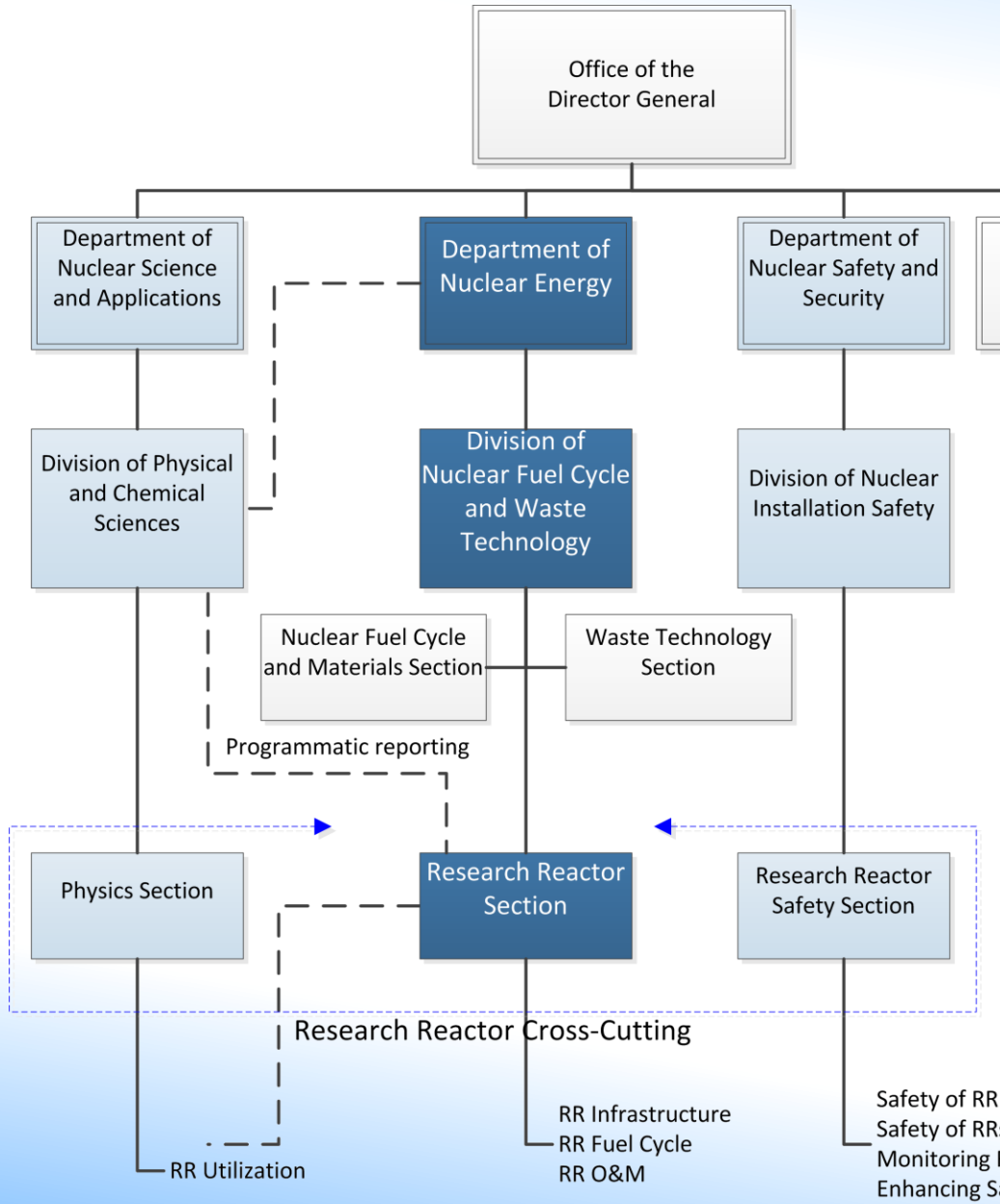
→ **Current status need to be updated.**

New RR Projects: tentative overview

Phase 1 (Consideration) Total: 23	Phase 2 (Preparatory Work) Total: 7	Phase 3 (Implementation) Total: 8
Azerbaijan	Belarus	Argentina
Bangladesh	Belgium	Brazil
China (2 facilities)	Bolivia	France (2 facilities)
Ethiopia	The Netherlands	Jordan (First criticality in 2016)
Ghana	Thailand (for BNCT at Univ.)	India
Japan	Vietnam	Republic of Korea
Kenya	USA	Russian Federation (3 facilities)
Kuwait		Saudi Arabia (Low Power RR)
Lebanon		
Malaysia		
Mongolia		
Myanmar		
Tajikistan		
Philippines		
Nigeria		
Saudi Arabia (Multipurpose RR)		
Senegal		
South Africa		
Sudan		
Tanzania		
Thailand (Multipurpose RR)		
Tunisia		
Zambia		

First criticality
(25 Apr. 2016)

Organization for IAEA RR Program



Research Reactor Section:

- Operation and maintenance
- Fuel cycle issues
- Planning and implementing new RR project, national infrastructure development.

Physics Section:

- Utilization and applications.

Research Reactor Safety Section:

- Enhancing safety of RRs

RRS Sub-programme 1.4.2

To support Member States in

- **enhancing sustainable operation and effective utilization of existing RRs,**
- **planning and implementing new RR projects, development national infrastructure,**
- **nuclear capacity building**
- **fuel cycle issues.**

Project 1.4.2.001
Utilization and Applications

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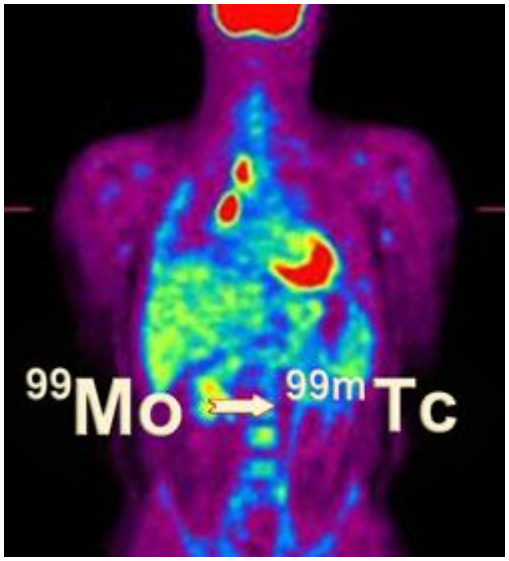
Bases:

- *RRs are ageing.*
- *Efficient utilization and well management for sustainable operations.*

Objectives:

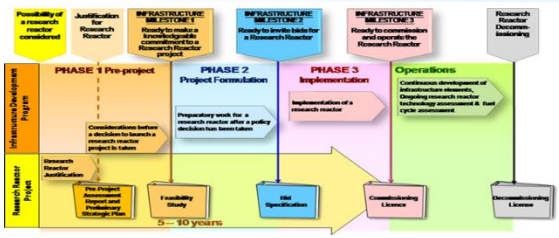
- **Enhancing RR utilization** for applications, such as isotope production, use of neutron beams, irradiation and analytical services, material characterization and testing, nuclear education and training,
- To increase **cooperation and resource sharing** between RR centres, promote and strengthen networking, including interested Member States without RRs,
- To assist **RR centres in development of user communities and industrial partnership**



Project 1.4.2.002
Infrastructure, Planning, Capacity building

Bases:

- *Planning or building the first RR in several MSs.*
- *Establishment of national infrastructure to ensure that national and international commitments and obligations, particularly regarding safety, security, safeguards and emergency preparedness, are met during construction, operation and decommissioning*
- *Need access of RRs for capacity building.*



Objectives:

- planning and implementing **new RR projects**, including the assessment and development of their national nuclear **infrastructure**,
- building and/or preserving national **nuclear capacity** using research reactors and **procurement of specific equipment and services**,
- **increasing access to RRs** for all MSs developing nuclear science and technology programmes, including nuclear power plants.

Project 1.4.2.003
Fuel Cycle Issues

Bases:

- *Assurance of new fuel supply.*
- *Non-proliferation, national policy, economics, and environmental concerns.*
- *The continued safe, reliable, and economic handling, management and storage of Spent Nuclear Fuel (SNF).*
- *Development and qualification for conversion of HEU to LEU.*

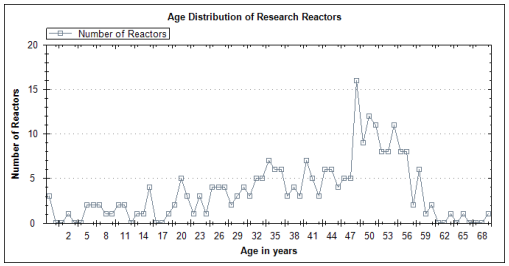
Objectives; Strengthening the capability of fuel cycle issues

- **fuel supply, development, fabrication and qualification of new fuels, SNF management and the back end of the fuel cycle.**
- To assist MSs, upon request, with the **conversion of HEU to LEU**
- **Repatriation of SNF** to its country of origin.

Project 1.4.2.004
Operation & Maintenance (O&M)

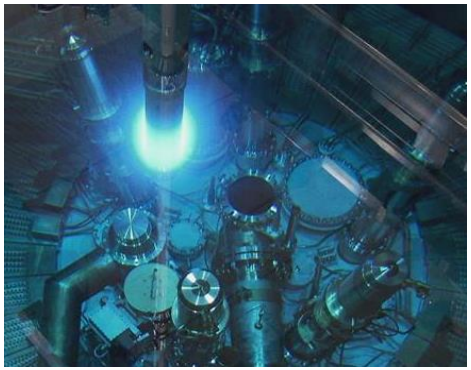
Bases:

- *Adequate life management programmes (ageing management and refurbishment/upgradation programmes).*
- *Adequate O&M plans & management system.*
- *Funding reduction for such facilities and limited succession planning, development, implementation of sound O&M, life management programmes.*
- *Two thirds of the RRs are in permanent shut-down state and need decommissioning.*



Objectives; To assist MSs in developing and implementing

- **operation and maintenance plans** to improve facility's operational performances and in establishing **integrated management systems**,
- **ageing management** and **renovation/upgradation programmes** for facility's life management,
- **decommissioning**.

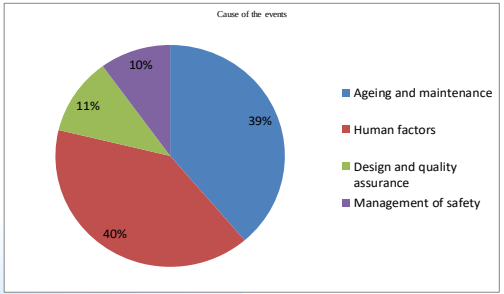


IAEA Safety Program for RRs

- **Application of the IAEA Safety Standards will help for the highest level of safety.**
- **The IAEA programme on the safety of RRs gives priority to the development and promotion of proper use of the IAEA Safety Standards through:**
  - Maintaining and expanding worldwide application of the Code of Conduct and the IAEA safety standards;
  - Supporting on ageing management and fuel cycle facilities;
  - Enhancing regulatory effectiveness, including infrastructure for the first research reactor projects;
  - Monitoring safety under Project and Supply Agreements – 27 research reactors in 23 countries;
  - Supporting on safety reassessments following the Fukushima accident;
  - Improving management of the interface between safety and security;
  - Improving exchange of operating experience through Incident Reporting System for Research Reactors (IRSRR) and networking.

Safety issues and challenges

- **Identification of safety issues and challenges.**
- **Update of programme and activities.**
- **Main sources of information;**
  - Feedback from ‘Code of Conduct’ meetings;
    - ✓ Self-assessments by 40 countries – International Meeting on Code of Conduct (2017) and the areas needing improvements are identified.
    - ✓ Main areas needing improvements: Resources (human and financial); Safety assessment; Decommissioning planning; Ageing management; Management system, and Culture for safety.
  - Feedback from IAEA safety reviews.
  - Feedback from the IRSRR;
    - ✓ Human Factors and Component Ageing are the two most important root causes of the incidents reported to the IRSRR.



IAEA Activities for RRs

- **Peer Review Missions to provide advice and assistance to MSs**
  - ✓ OMARR
    (Operations and Maintenance Assessment of Research Reactors)
  - ✓ INIR-RR
    (Integrated Nuclear Infrastructure Review of Research Reactors)
  - ✓ INSARR
    (Integrated Nuclear Safety Assessment of Research Reactors)
  - ✓ IRRUA
    (Integrated Research Reactors Utilization Assessment)
- **Establishment of networks and coalitions;**

Nuclear safety networks, Regional advisory safety committees, Internet Reactor Laboratory (IRL), Int'l Centres based on Research Reactors (ICERR)

- **Capacity building through training workshops and courses**
  - ✓ Distance training through IRL
  - ✓ Regional Research Reactor Schools
  - ✓ EERRI group fellowship course
  - ✓ Advanced training at ICERR
  - ✓ Publish and promote the E-learning NAA tool

IAEA Activities for RRs

- **Exchange of experiences**
  - ✓ Consultancy Meetings – specific focus
  - ✓ Technical Meetings
  - ✓ Workshops / Training Courses
  - ✓ International Conferences and Symposia
  - ✓ International Expert Meetings
- **Coordinated Research Projects (CRP)**
- **Technical Working Group on RRs**
- **Technical Cooperation projects related to RRs**
- **Visual Inspection with IAEA Radiation Resistance Cameras**
- **Publications (standards, guidance, and other documents)**
- **IAEA Databases**
  - ✓ RRDB (Research Reactors Database)
  - ✓ RRADB (Research Reactors Ageing Database)
  - ✓ RRMPDB (Research Reactors Material Properties Database)

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More details through

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Thank you!

Annexes

- More databases
- RR Networks and Coalitions
- Brochure for OMARR
- Brochure for Capacity Building

IAEA RRDB – Application

Application	Number of RR	Number of countries
Education & Training	166	53
Neutron activation analysis	120	53
Radioisotope production	97	43
Material/fuel testing/irradiations	80	27
Neutron radiography	72	38
Neutron scattering	48	31
Si doping	28	18
Geochronology	26	22
Gem coloration	21	12
Neutron therapy	17	12
Nuclear energy research	16	11
Nuclear data measurements	4	4
Other	130	38

- ✓ Number of operational RR is decreasing
- ✓ >50% of RRs are not utilized to full potential
- ✓ Ageing, including staff; need constant modernization/refurbishment
- ✓ Absence of clear utilization purpose & strategy; lack of necessary budget

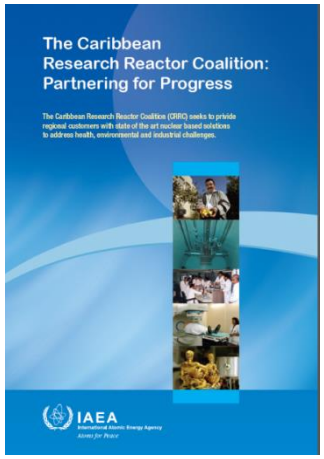
RRADB: RR Ageing Database

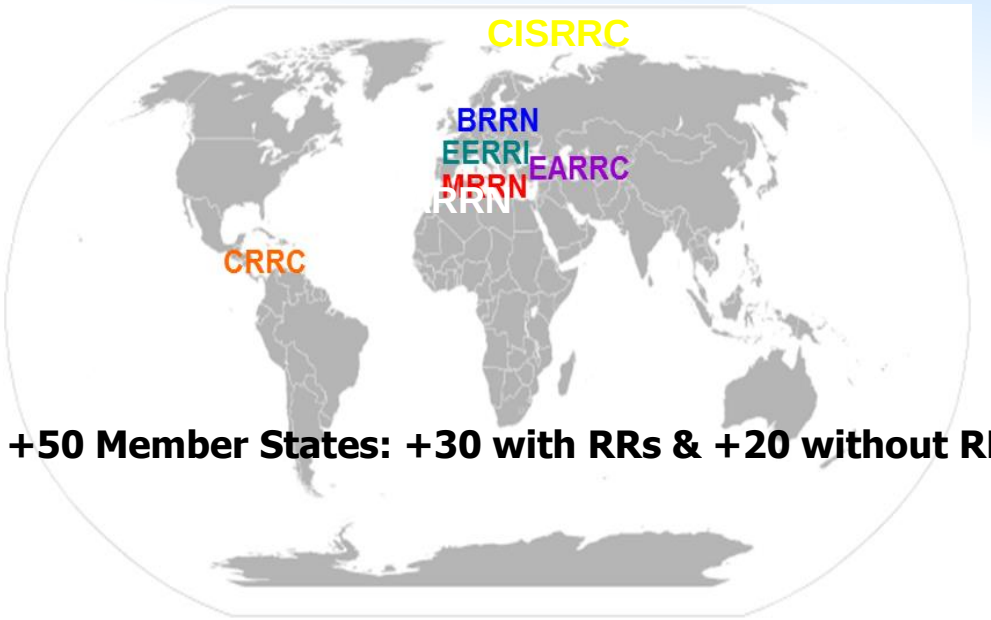
- 298 reports on ageing issues for RR components
  - ageing mechanism, mitigating or corrective actions.
  - update every 2 years.

RRMPDB: RR Materials Properties DB

- 136 reports through CRP on ‘Establishment of Material Properties Database for Irradiated Core Structural Components for Continued Safe Operation and Lifetime Extension of Ageing Research Reactors;
  - Materials
  - Components
  - Ageing mechanism

RR Networks and Coalitions:





+50 Member States: +30 with RRs & +20 without RRs

EERRI	Eastern European RR Initiative,	multipurpose,	6 MS
CRRC	Caribbean RR Coalition,	mainly NAA,	3 MS
EARRC	Eurasian RR Coalition,	isotope production,	5 MS
BRRN	Baltic Research Reactor Network,	multipurpose,	10 MS
MRRN	Mediterranean RR Network,	multipurpose,	12 MS
CARRN	Central Africa RR Network,	multipurpose,	9 MS
CISRRC	CIS RR Coalition,	multipurpose,	7 MS
GTRRN	Global TRIGA RR Network,	multipurpose,	17 MS

OMARR

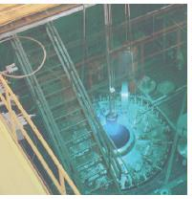
Operation and Maintenance Assessment for Research Reactors

Improve operational performance of research reactors by sharing good practices



Improve maintenance and ageing management programmes for long-term operation of research reactors


Establish and improve management system at research reactors

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OBJECTIVES OF OMARR

The Operation and Maintenance Assessment for Research Reactors (OMARR) mission provides advice and assistance to Member States in enhancing the performance of research reactors. The mission is aimed at improving operation and maintenance (O&M) practices throughout the facility's operational life cycle. The expected results include a more efficient long-term operation, better performance, improved safety and safety culture, and optimized utilization of human and financial resources.

The main objective of an OMARR mission is to conduct an O&M review of a research reactor facility. It identifies areas for improvement, addresses specific operational challenges, and creates a space for sharing experiences and good practices. Recommendations of an OMARR mission can also be used to prepare strategic plans for ageing management, refurbishment and modernization of a facility. Identified improvements, lessons learned and good practices at a given facility may be shared with other operational organizations with the consent of the facility. An OMARR mission promotes exchange of knowledge and experience between international experts and facility personnel, as well as development of self-assessment capabilities and continuous improvement of a research reactor facility.

SCOPE

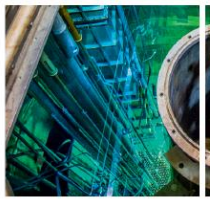
An OMARR mission is performance oriented and focuses on good practices in O&M management. It can contribute to improving reliability for research reactors' long-term operation and use, regardless of their design, power level and age. The mission provides recommendations and suggestions in the areas that include but are not limited to:

- Operational plans, procedures and practices, including operational performance indicators;
- Maintenance plans, procedures and practices, including non-destructive examination and in-service inspections;
- Ageing management plans and practices;
- Human resources development, including for technical services;
- Quality assurance and integrated management system;
- Plant asset and configuration management;
- Plant modification and/or refurbishment.








APPROACH

Pre-OMARR
A preparatory Mission

Duration: 2–3 days

A facility conducts self-assessment and requests an OMARR Mission through official channels.

- **Request for OMARR Mission**
  - Self-assessment by facility
  - Facility documents
- **Pre-OMARR**
  - 1 IAEA staff
  - 2 international experts
  - Facility staff
- **Discussion**
  - Current status review
  - Future plans review
  - Identify areas needing attention
- **Scope of OMARR identified**

4–12 months

The Pre-OMARR Mission is generally conducted 4 to 12 months before the main Mission, by a team comprised of one IAEA staff member, up to two international experts with relevant O&M experience and required facility staff.

The purpose is to identify the scope and methodology of the main OMARR Mission with the operating organization.

OMARR
The main Mission

Duration: 5–7 days

The main OMARR Mission is generally conducted by a team of two IAEA staff members, up to four international experts with relevant experience and required facility staff. The size of the team and the duration of the main Mission depend on the complexity of the facility and topics to be reviewed. Observers from organizations receiving a future OMARR Mission may be invited to participate with the consent of the hosting organization (and country).

- **OMARR**
  - 2 IAEA staff
  - 3-4 international experts
  - Facility staff
- **Assessments and evaluations at RR**
  - Assessment of current status of O&M
  - Identification of opportunity for improvement
  - Development of Action Plan
- **Implementation initiated**
- **Report**
  - Assessment results, including identified good practices and opportunities for improvement
  - Recommendations
  - Suggestions

Post-OMARR
A follow-up Mission

Duration: 3–5 days

The follow-up OMARR Mission is undertaken if requested by the facility. It is generally conducted by a team of one IAEA staff member, one or two experts with relevant experience and required facility staff.

The Mission focuses on the review and implementation of the main OMARR Mission recommendations and suggestions.

- **Request for post-OMARR Mission**
  - 1 IAEA staff
  - 1-2 international experts
  - Facility staff
- **Joint review**
  - Need for mid-course correction
- **Report**
  - Implementation assessment
  - Modified Action Plan

The OMARR Mission addresses the topical areas described in IAEA Nuclear Energy Series No. NP-T-5.4

Optimization of Research Reactor Availability and Reliability: Recommended Practices

BENEFICIARIES

The Mission is available, upon request, to all Member States with research reactors under commissioning or in operation. OMARR Mission can also assist an operating organization carrying out a major refurbishment or modernization of their facilities in identifying the structures, systems and components to be replaced.

It is also useful after a major refurbishment or modernization of a research reactor facility in identifying ways to improve O&M programmes and procedures.

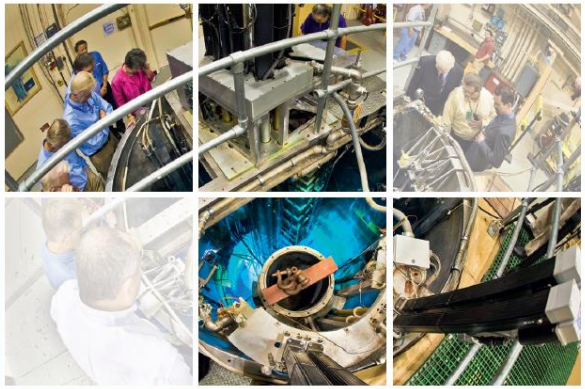
OMARR missions were initiated in 2012. The IAEA has completed two pilot OMARR missions: at the 20 MW RR at the National Institute of Standards and Technology (NIST), in the United States of America, and at the 250 kW RR at the Applied Nuclear Energy Laboratory (LENA) at the University of Pavia, in Italy.

OUTPUTS

The IAEA provides an OMARR mission report to the research reactor operating organization. The operating organization can share the report with other stakeholders.

OMARR report includes:

- **Recommendations:** advice on how to resolve identified issues, addressing root causes rather than the effects of the issues. Recommendations are generally based on proven methods for achieving excellence.
- **Suggestions:** additional proposals that may indirectly contribute to improvements in operational performance, effectiveness and safety.
- **Good practices:** performance, activity or use of equipment, which the team considers to be markedly superior to that observed elsewhere, and fit for emulation by other facilities.



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Nuclear Capacity Building

based on research reactors

Overview of the IAEA training programmes based on research reactors

Targeted Audience	Distance training: Internet Reactor Laboratory (IRL)	Basic Training: Regional Research Reactor Schools	Intermediate Training: EERRI Group Fellowship Course	Advanced training: International Centers based on Research Reactors (ICERR)
	5 to 6 half-day sessions	2 weeks	6 weeks	A few weeks to a few months
Undergraduate and Graduate Students (Nuclear engineering or related fields)	***Agreement to be signed with the IAEA to become a Guest institution*** *IAEA may provide financial support to the Guest institutions for the procurement of the necessary equipment.* *Laboratories are broadcasted free of charge for the Guest Institutions (1 set of sessions per year for a maximum of 5 years)*			
Young professionals (Nuclear engineering or related fields)	***Bilateral arrangement to be made between a Host reactor and a Guest institution*** *IAEA acts only as a facilitator*	***Schools held by the hosting organizations, in cooperation with the IAEA*** *Funding might be provided through established mechanisms (e.g. under relevant TC projects or extra budgetary contributions)*	***EERRI Course held by the hosting organizations, in cooperation with the IAEA*** *Funding might be provided through established mechanisms (e.g. under relevant TC projects or extra budgetary contributions)*	***Bilateral arrangement to be made between the ICERR and an Affiliate institution*** *IAEA act as a facilitator but, if applicable, funding might be provided through established mechanisms (e.g. under relevant TC projects or extra budgetary contributions)*
Professionals seeking for advanced and specific training				***Bilateral arrangement to be made between the ICERR and an Affiliate institution*** *IAEA acts as a facilitator but, if applicable, funding might be provided through established mechanisms (e.g. under relevant TC projects or extra budgetary contributions)*

Note: Trainers, university professors or reactor staff who wish to improve their skills in developing and delivering hands-on-training courses at their national facilities, may also join the distance IRL training, hands-on-training at the Regional Research Reactor Schools, or attend part of the EERRI hands-on-training Group Fellowship Course (e.g. for 2 weeks) to get an insight into the content and pedagogical approach (train-the-trainers approach).

Distance Training: Internet Reactor Laboratory

Basic Training: Regional Research Reactor Schools

Intermediate Training: EERRI Group Fellowship Course

Advanced Training at International Centres Based on Research Reactors (ICERRs)

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IAEA 60 Years Atoms for Peace and Development

The IAEA has developed a set of services to support building of nuclear competence using research reactors. These services are available, upon request, to Member States interested in using research reactors as a primary facility to develop national nuclear science and technology programmes, including as a supporting step to embark on a national nuclear power programme. The IAEA currently offers four complementary instruments, each of them targeting specific objectives and audience.

Distance Training: Internet Reactor Laboratory (IRL)

IRL connects an operating host research reactor to guest institutions, usually Universities within the same region of the world. It provides live connection, via the Internet, with a research reactor and enables participants to interact with the reactor team and be actively engaged in performing reactor physics experiments. Intended for participants from Member States without a research reactor, the objective is to complement theoretical lectures by a practical insight into reactor physics as well as research reactor safe operation and applications.

Five to six half-day sessions are broadcasted every year, within the framework of an agreement signed between the IAEA, the host research reactor and the guest institutions. Reactor experiments include neutron flux monitoring, criticality experiments, reactor start-up, control rod calibration, temperature coefficient measurement, and study of the reactivity effects of devices/materials inserted in the reactor core.

The IRL sessions are mainly intended for students of nuclear engineering and nuclear physics. They can also be extended to other audiences, such as nuclear professionals, offering tailored experiments or demonstration exercises.

Basic Training: Regional Research Reactor Schools

Regional Research Reactor Schools provide basic knowledge and hands-on-training on reactor physics and research reactor operation and utilization. They provide a unique on-site training experience at different research reactors of the region. The objective is to assist Member States build and further develop nuclear competence, by providing basic background and technical skills for safe and sustainable operation of research reactors, including their efficient utilization.

The school combines theoretical classes and hands-on experimental activities. Topics include reactor physics, reactor kinetics and dynamics, basic concepts of safety, security and safeguards, radiation protection, neutron and gamma detection, research reactor operation as well as various research reactor applications. The practical part of the school includes facility walkthrough and extensive hands-on reactor experiments. In general, the two week school takes place successively at two different reactor facilities, located in two different countries of the region.

The school is intended for young professionals with a technical degree in nuclear engineering, nuclear physics or related fields. Their current or future assignment is generally linked to existing research reactor facilities or reactors in advanced planning stage. Participants from Member States planning to embark or embarking on a nuclear power programme, can also gain benefit from attending these schools.

Intermediate Training: EERRI Group Fellowship Course

The Eastern Europe Research Reactor Initiative (EERRI) was established with the IAEA's support in 2009 and further strengthened through Practical Arrangements between the IAEA and the EERRI partner organizations in 2016. The EERRI fellowship training course offers an extensive hands-on-training in at least two different research reactors of EERRI partner organizations: Technische Universität Wien – Atominstitut (Austria); Czech Technical University – Faculty of Nuclear Sciences and Physical Engineering (Czech Republic); Jozef Stefan Institute (Slovenia); and Budapest University of Technology and Economics – Institute of Nuclear Techniques (Hungary). The objective is to support Member States in building their nuclear competence at large and providing research reactor based hands-on-training. The course also offers a learning opportunity to support activities related to planning, commissioning, operation and effective utilization of research reactors.

The course includes theoretical classes, facility walkthrough and hands-on experiments. It covers a broad range of topics related to reactor physics, kinetics and thermal-hydraulics, research reactor operation, maintenance and utilization, nuclear safety, security and safeguards considerations, radiation protection as well as introduction to nuclear power plants. Throughout the course, participants undergo tests and evaluations, and they receive an attendance certificate upon the completion of the course.

The training is intended for young professionals with degrees in engineering and science and preferably with some experience in the nuclear field. Participants' current or future assignment is generally linked to a national research reactor or nuclear power programme. The course can be adapted and modified into a train-the-trainers course for professors or experienced research reactor staff who wish to improve their training skills.

Advanced Training at International Centers based on Research Reactors (ICERR)

The IAEA designated ICERRs are intended to help Member States gain access to state-of-the-art research reactor facilities and related infrastructure to achieve their nuclear research and development and capacity building objectives. Member States wishing to gain access to an ICERR have to become an Affiliate by signing a bilateral agreement with the ICERR. The IAEA facilitates this process, also through the sharing of the information on the capabilities offered by the ICERRs.

ICERRs can provide a range of services to support nuclear capacity building, such as:

- basic to specialized training for professionals in nuclear science and engineering (e.g. reactor laboratories, development of joint projects);
- hands-on-training related to specific activities of research reactors (e.g. irradiation and testing services) or their ancillary facilities (e.g. operation of hot cells or analytical laboratories);
- on-the-job training for research reactor and hot cells operators, maintenance personnel, radioprotection specialists or regulators.

The main objective of these types of trainings is to foster knowledge, rules- and skill-based behaviors, as well as to develop the nuclear safety culture. Duration of the training can range from a few weeks to a few months, depending on needs and training objectives. ICERR and its Affiliate institute are expected to jointly prepare the detailed content of the training programme.

Training at ICERRs is particularly well suited for professionals with some experience in research reactor operation, maintenance and utilization. It can also be used for initial education and training.

"Thanks to the IAEA nuclear education and training programme I gained experience and knowledge which will help me in my work and in particular in our project for the implementation of sub-critical reactor in Tunisia."

Kamel Harzli, Energy Engineer, Centre National des Sciences et Technologies Nucléaires, Tunisia