Research Reactor Safety – Trends, Issues, and IAEA Activities

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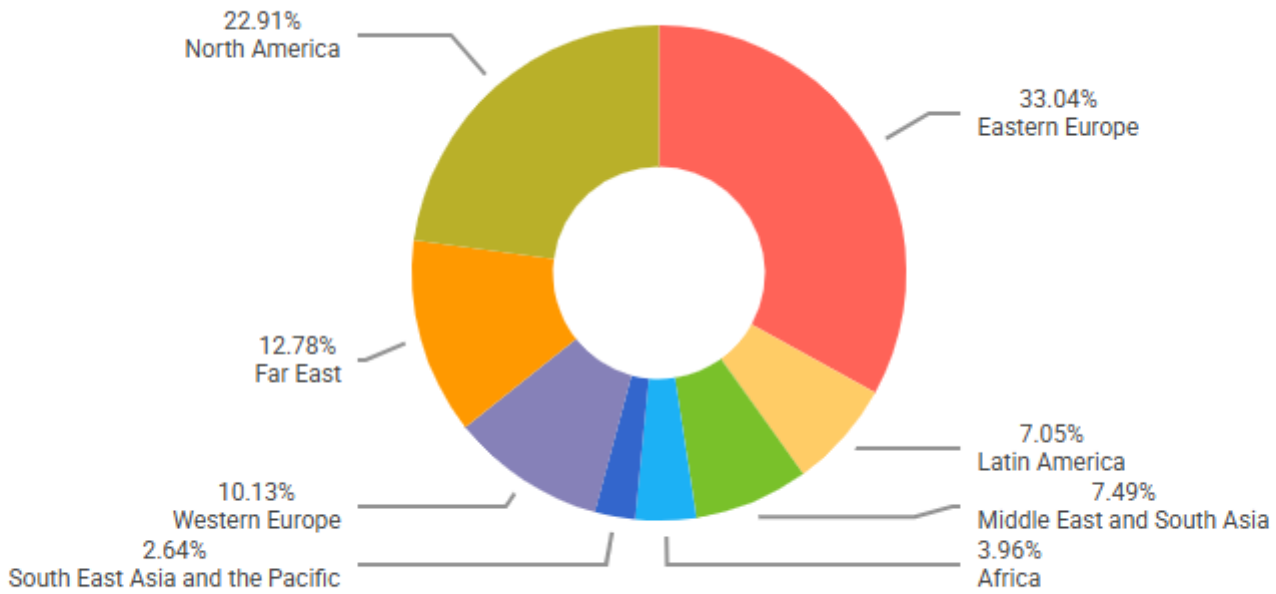
Overview of Research Reactors

Total
847 Reactors
in 72 countries

Operational
227 Reactors
in 54 countries

Under construction/Planned
23 Reactors
in 18 countries



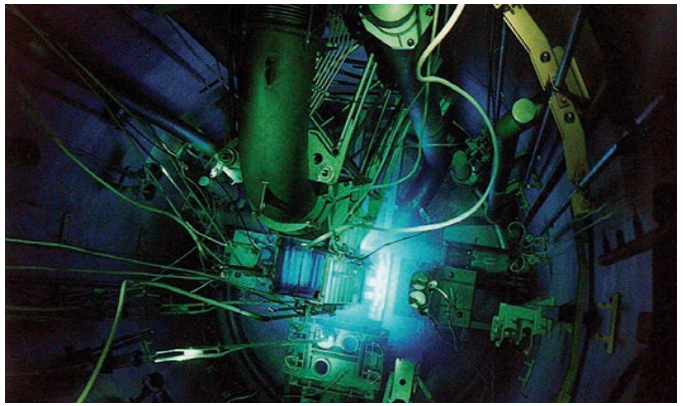
https://nucleus.iaea.org/RRDB/ *(June 2025)*

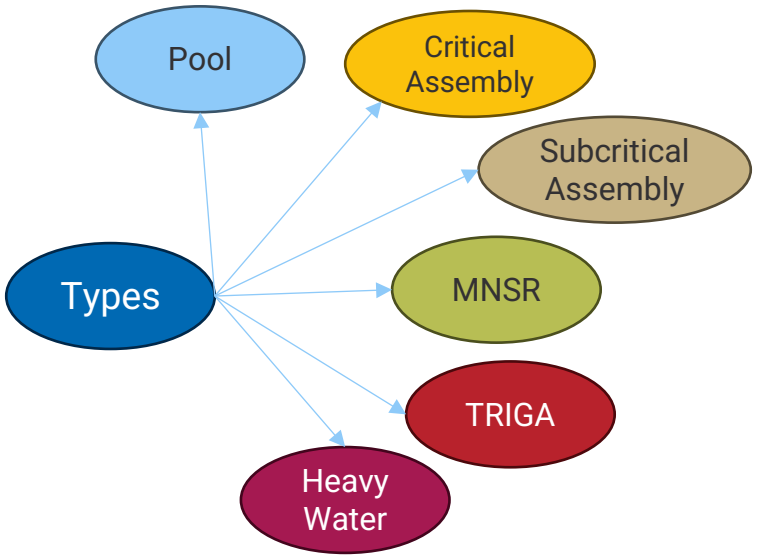
Research Reactors Worldwide

847 Research Reactors in 72 Countries

Planned (13)	Under Construction (10)	Operational (227)	Temporary Shutdown (7)	Extended Shutdown (10)
Belgium	Argentina	North America (52)	Argentina	Belarus
Brazil	Bolivia	Latin America (16)	Germany	Chile
China (3)	Iran (2)	Western Europe (23)	Japan (2)	China
India (2)	Korea	Eastern Europe (75)	Libya	DRC
Mongolia	Russian Federation	Africa (9)	Russian Federation	Egypt
Netherlands	Saudi Arabia	Middle East and South Asia (17)	Serbia	Greece
Thailand	Tajikistan	Southeast Asia and the Pacific (6)		Mexico
Ukraine	Ukraine	Far East (29)		Russian Federation (2)
Viet Nam				Türkiye

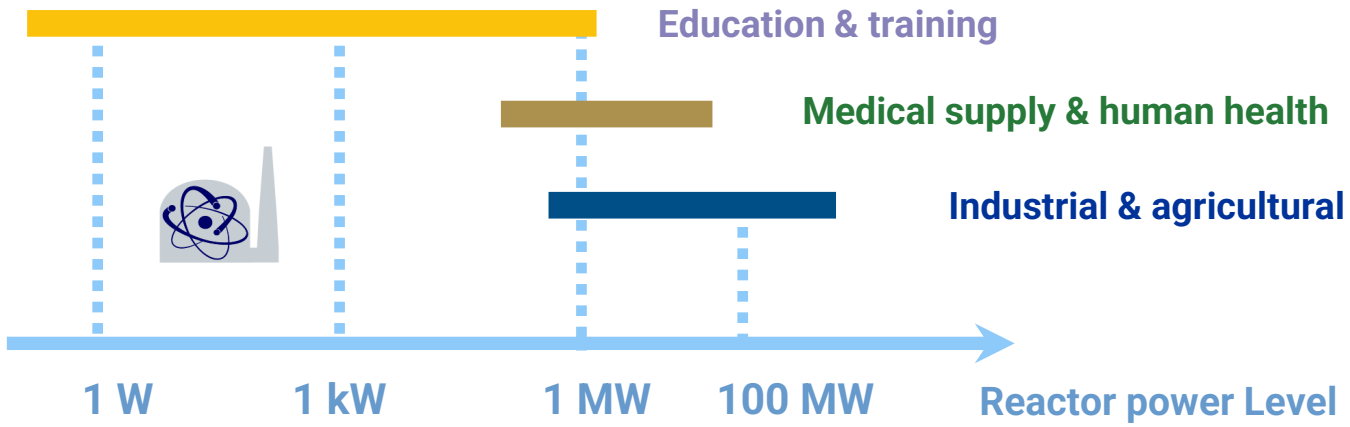
https://nucleus.iaea.org/RRDB/ *(June 2025)*





Research Reactors – Applications and Utilization

- **Education & training**
  - Students and professionals
  - Infrastructure for nuclear power
  - R&D
- **Medical supply & human health**
  - Radioisotope production
  - Boron-neutron capture therapy
- **Industrial & agricultural**
  - Neutron activation analysis
  - Radiography
  - Fuel & materials testing
  - Reactor concept prototyping
  - Silicon doping
  - … and others



IAEA Programmes and Activities

Ensuring safety is essential for effectiveness and sustainability of research reactors.

IAEA programmes and activities are tailored to address the identified trends, challenges, and needs of MSs.

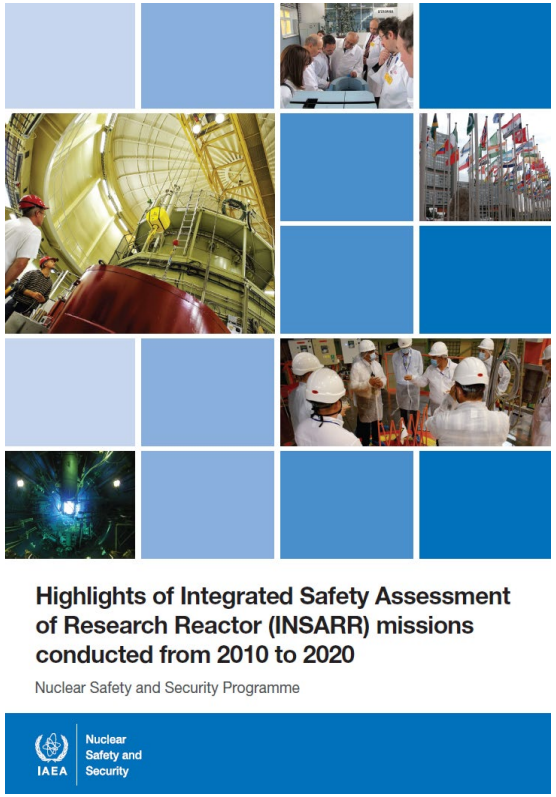
The programme focuses on:

- Assistance on application of the Code of Conduct on the Safety of Research Reactors;
- Development of IAEA safety standards; and
- Supporting application of the standards through peer reviews, capacity building, and international cooperation.

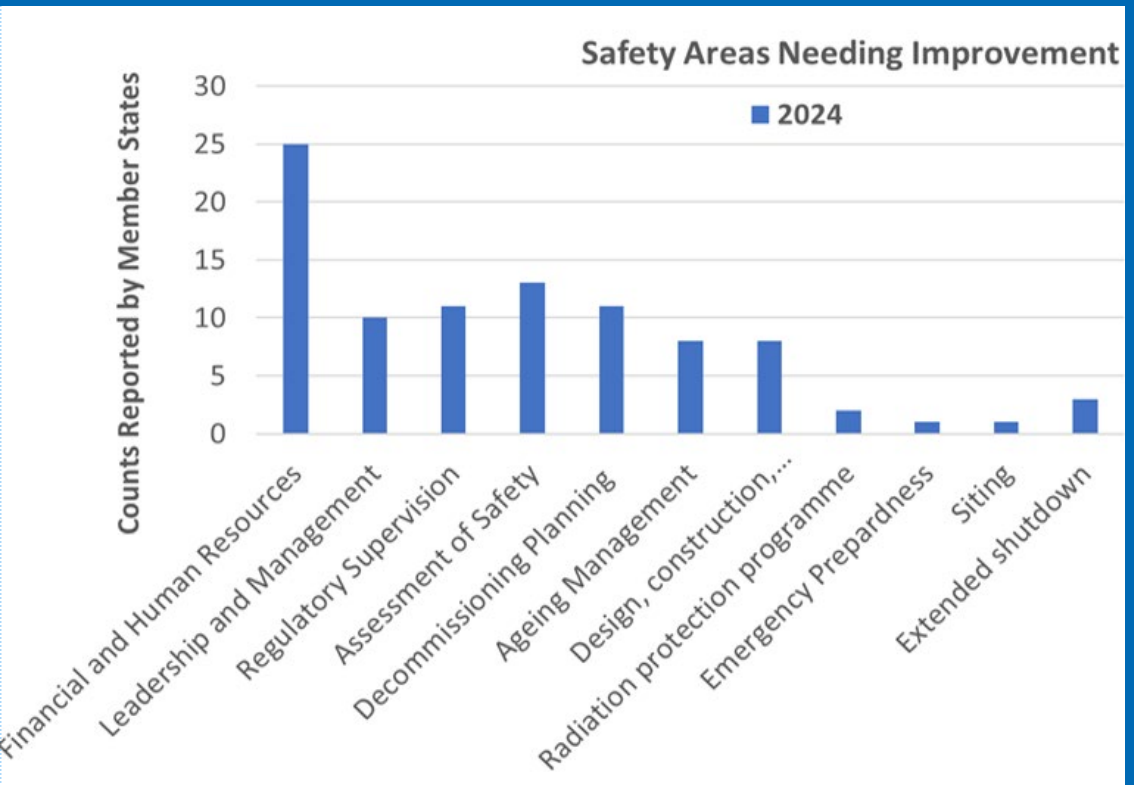
Issues and Challenges

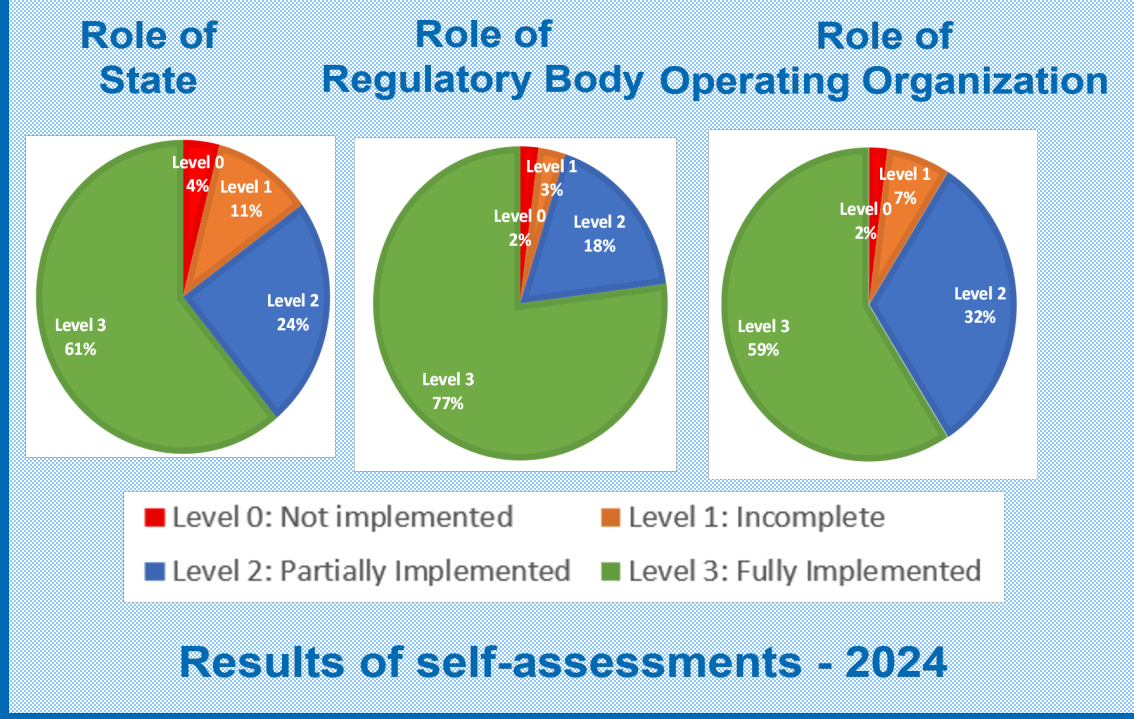
Identification of Member States' needs and priorities through:

- Reports of self-assessments of Code of Conduct;
- Results of IAEA safety review (INSARR) missions;
- Feedback from events reported to the IRSRR;
- Insights from Member States' needs (requests, conferences, meetings, working groups, and IAEA Technical Co-operation).



Self-assessments of the Code of Conduct- IAEA triennial international meetings since 2007 (40 Countries).

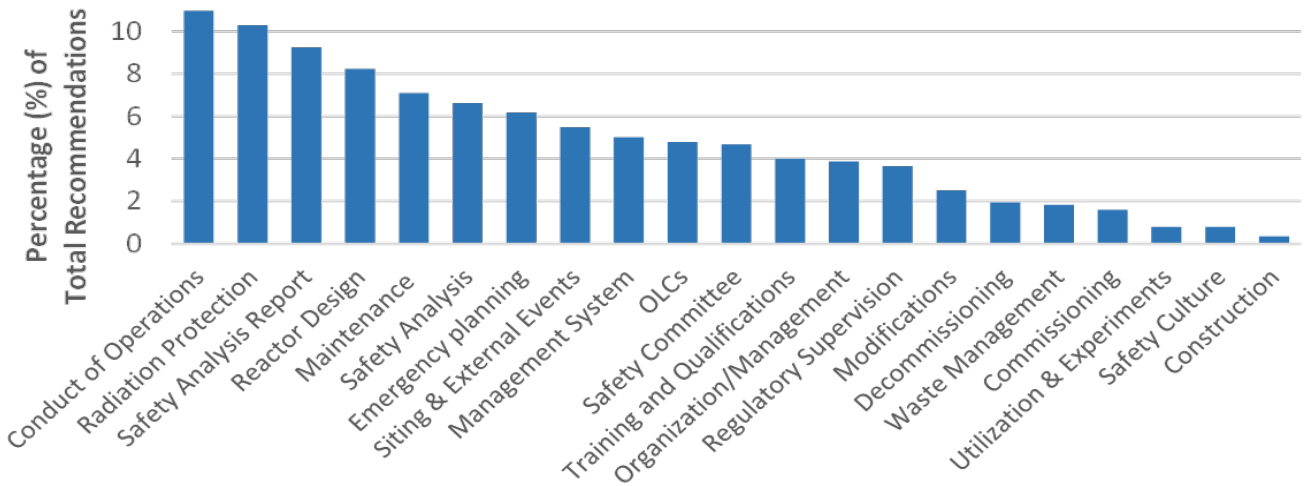


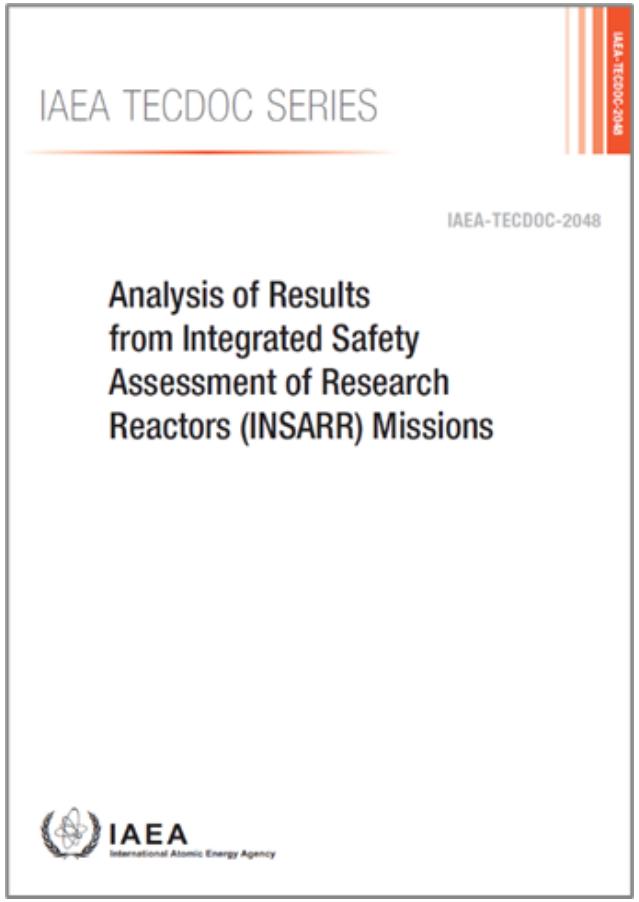


- Progress in regulatory supervision, ageing management, and safety of reactors in extended shutdown.
- Improvements needed in human and financial resources, safety management, and preparation for decommissioning.

Issues and Challenges

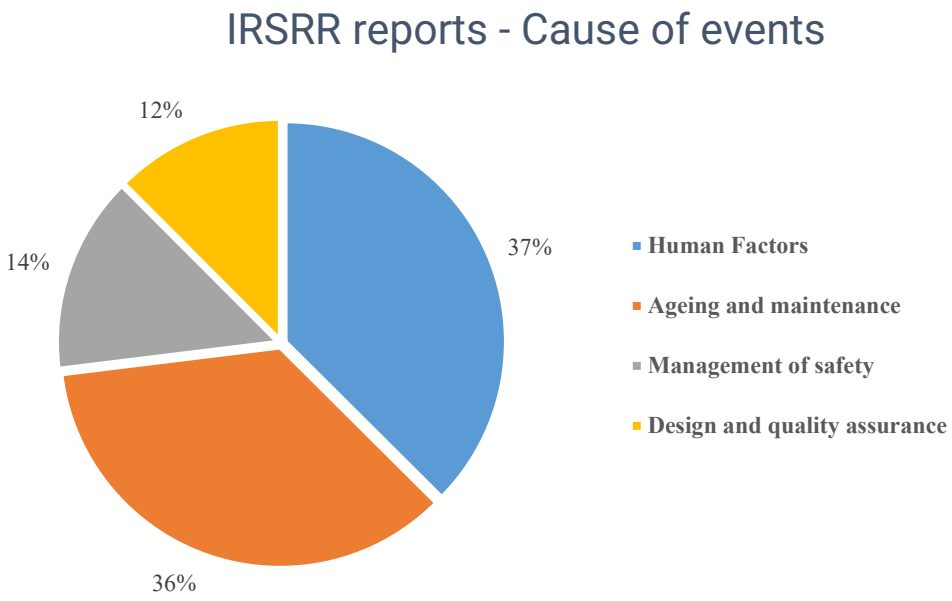
- Results of more than 100 INSARR missions showed improvement in several operational safety programmes, but also showed need for improvement in:
  - *Organizational effectiveness;*
  - *Ageing (and long-term operation);*
  - *Safety analysis;*
  - *Preparation for decommissioning;.*

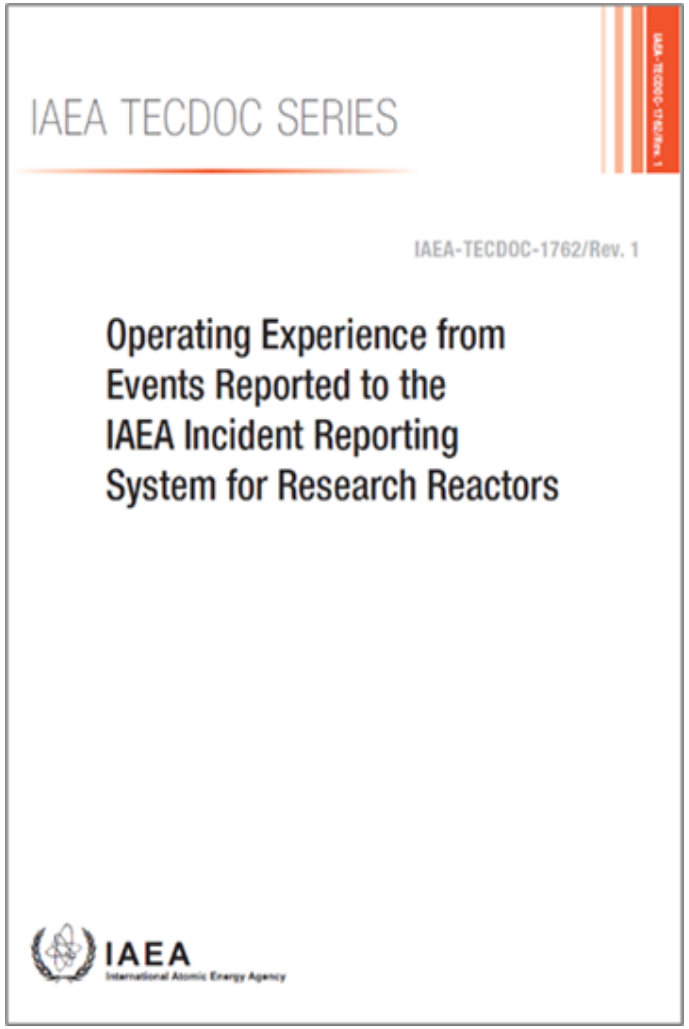




Issues and Challenges

- Ageing of facilities, and inadequate consideration of human factors are the main causes of events reported to the IRSRR





Issues and Challenges

- Security of fuel supply (for some types of reactors).
- Need to manage spent fuel and planning for decommissioning.
- Coordinated nuclear safety and nuclear security to ensure measures in one area don't undermine the other.

Issues and Challenges

Advances in technology: Exponential growth of use of digital technology and consideration of use of AI applications - improves effectiveness but has safety implications:

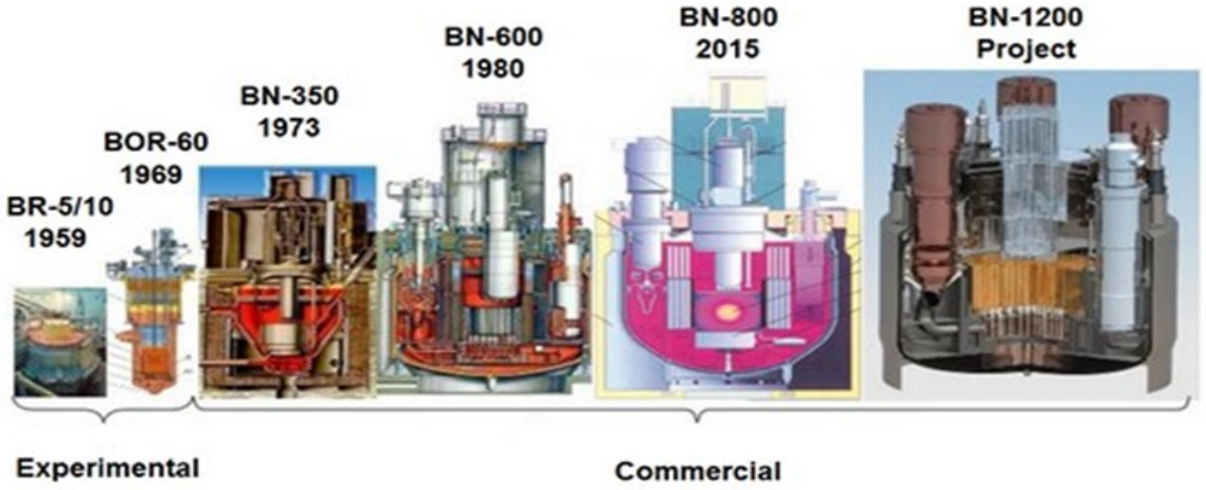
- *Potential interface with safety performance;*
- *Complex software validation and verification;*
- *Independence of SSCs important to safety;*
- *Autonomous operation and control systems;*
- *Human factors;*
- *Computer security;*
- *Gaps in the current regulatory framework.*

Issues and Challenges

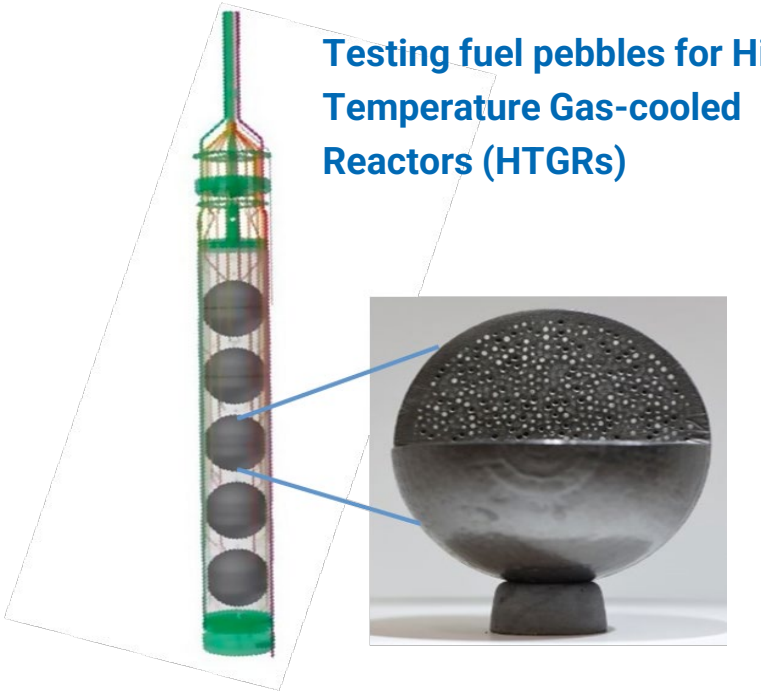
Expansion of nuclear power:
Research reactors can be used for concept prototyping, and test new fuel for innovative reactors.

However, regulatory framework needs to adapt and the continued need to pay attention to safety of experimental devices remains.

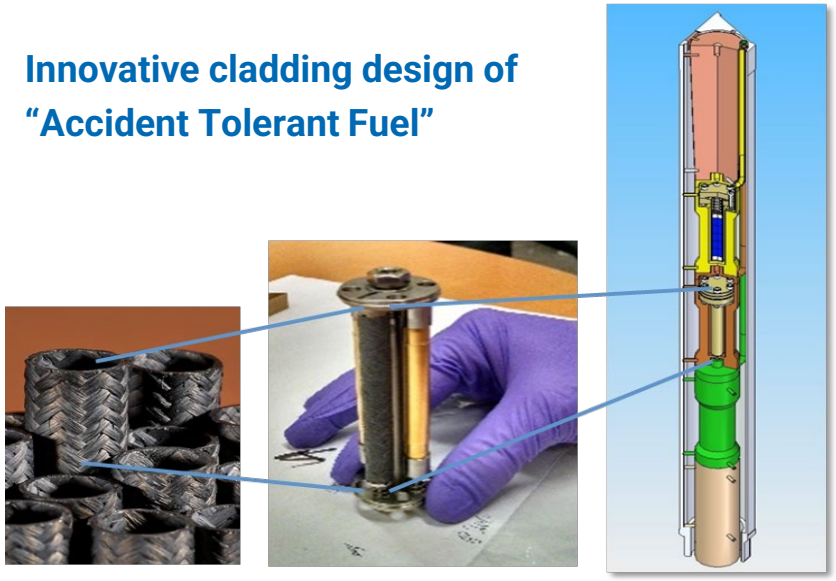
Evolution of Sodium Fast Reactors, Russia



Testing fuel pebbles for High Temperature Gas-cooled Reactors (HTGRs)



Innovative cladding design of "Accident Tolerant Fuel"

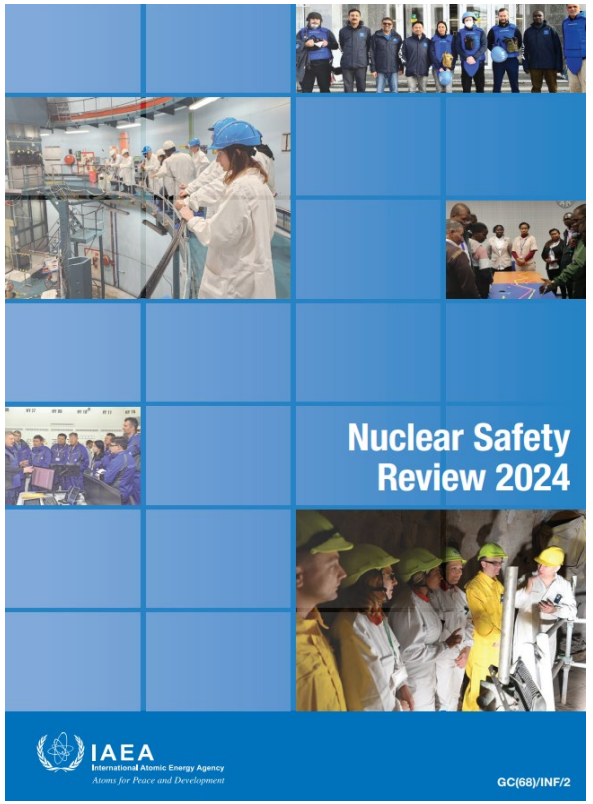


Issues and Challenges

- New (and expanding) users: 23 new research reactor programmes in 17 countries, most with limited nuclear infrastructure.
- Need to establish sustainable regulatory infrastructure.

Issues and Challenges - Summary

- Regulatory effectiveness;
- Leadership and management for safety;
- Ageing (LTO and PSR);
- Decommissioning planning;
- Utilization & strategic planning;
- Nuclear infrastructure for new programmes.



Managing the interface between nuclear safety and security, and safety considerations in use of advanced technology (digital I&C and AI) were also highlighted.

IAEA Assistance – An Overview

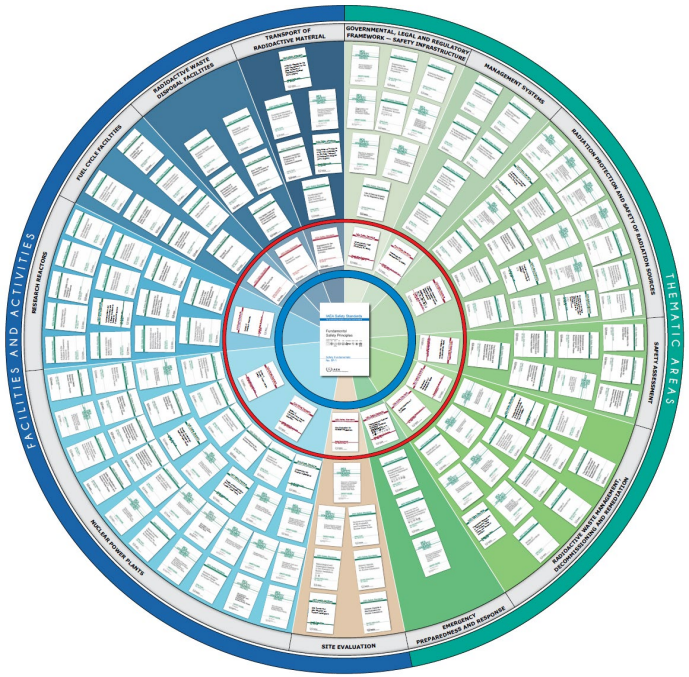
MSs priorities

- Enhance and sustain safety infrastructure and regulatory framework for new and existing programmes
- Ensure safety in all stages of facilities lifetime, including management of ageing, spent fuel, and decommissioning
- Addressing emerging trends and challenges – use of advanced technology and innovative reactors

Through:

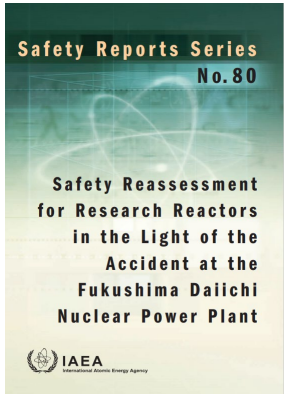
- Developing safety standards & supporting documents
- Supporting application of the Code of Conduct
- Organizing peer reviews and advisory services
- Supporting capacity building (E&T, knowledge management and info networks)

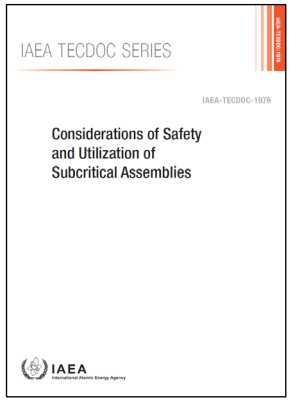
Based on:

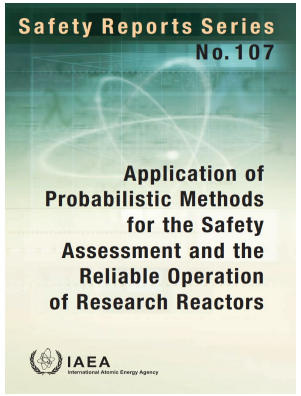


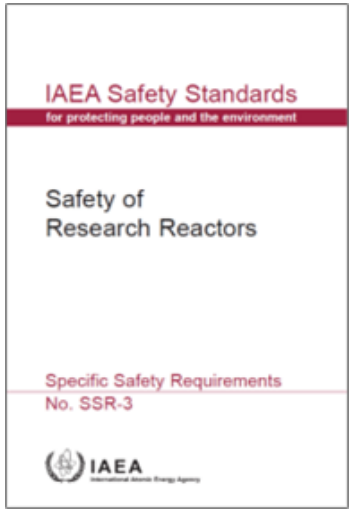
IAEA Assistance – Safety Standards

- Development of up-to-date safety standards covering all areas important to safety and support their application – Safety Requirements and 11 Safety Guides (2022-2024), cover lessons learned from Fukushima accident.
- Assistance to adopt IAEA safety standards in national regulations.





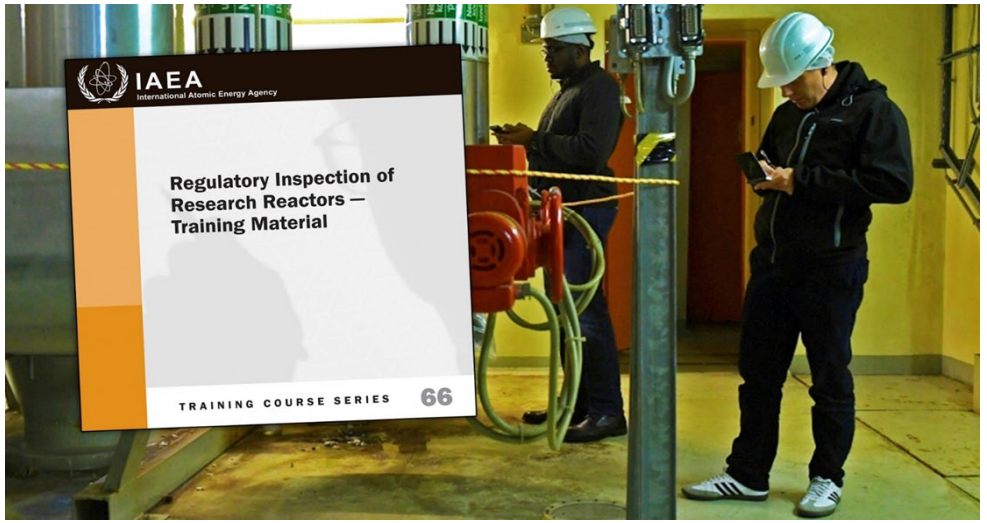




Publication of technical guidelines such as Safety Report Series and TECDOCs (20 since 2015).

IAEA Assistance – Regulatory Supervision

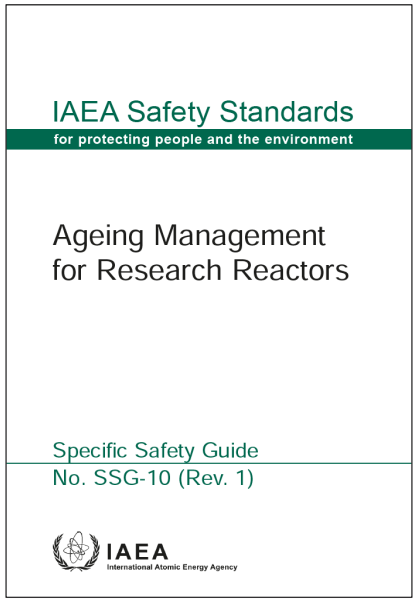
- *Capacity for review and assessment & inspection programmes (training, meetings, peer reviews, self-assessment guidance);*
- *Model inspection programme for member states – shared with other states within regional association activities.*

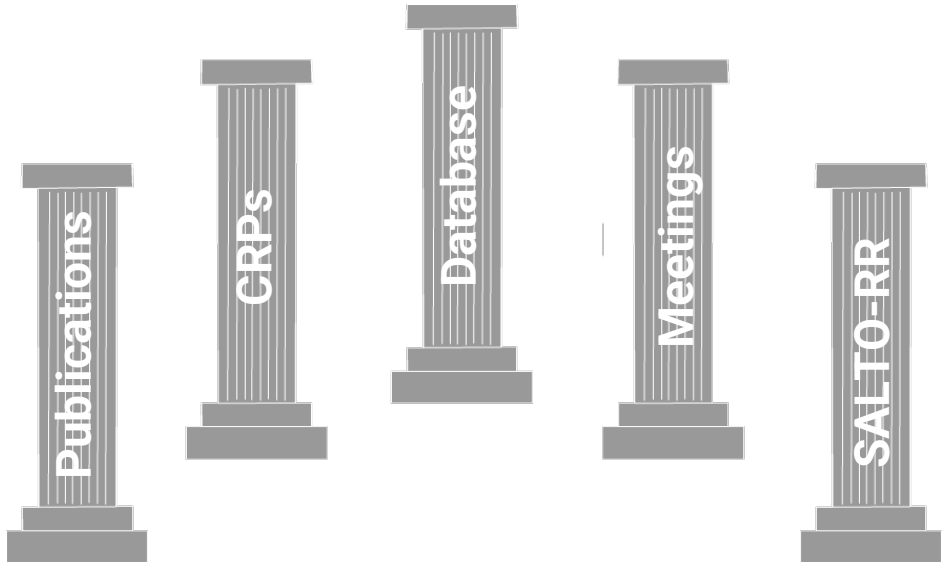


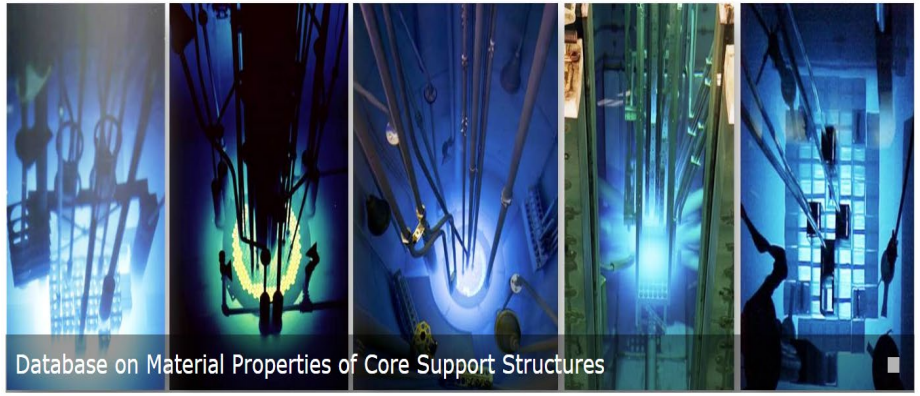
- IAEA assisted in developing national safety requirements and provided hands-on training on inspection (189 persons from 29 countries).
- Several member states have hosted training workshops.
- Regular meetings on regulatory supervision

IAEA Assistance – Ageing Management

- Capacity for managing aging of facilities, including SALTO-RR and OMARR peer review services.



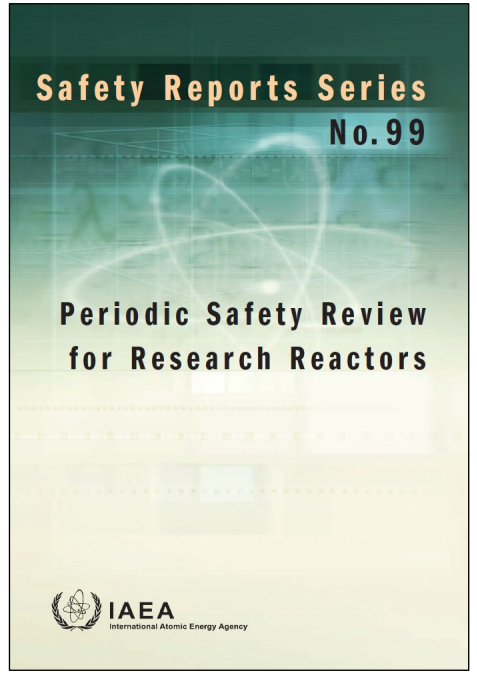




Welcome to the IAEA Research Reactor Material Properties Database

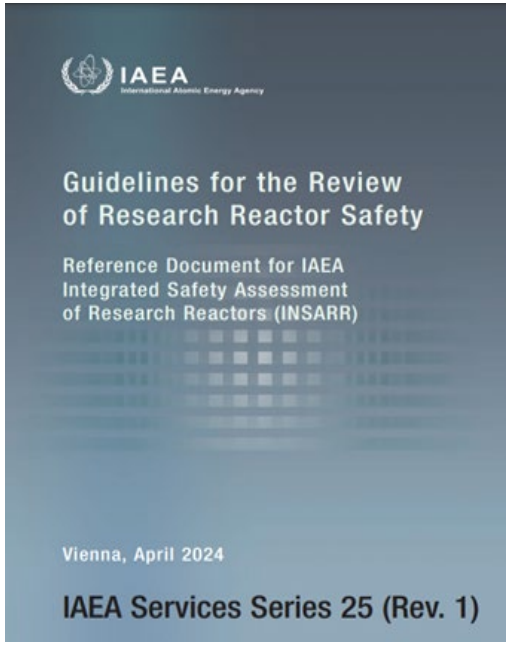
IAEA Assistance – Periodic Safety Reviews

- Planning and implementing processes for periodic safety reviews, aiming at identification and implementation of practicable safety upgrades based on up-to-date safety standards; supporting long-term (continued safe) operation.
- IAEA SRS No 99, advisory missions, and regular meetings.



IAEA Assistance – Peer Reviews and Operational Safety

- Peer reviews (INSARR): Assist in enhancing operational safety programmes, through improvement in organizational and technical measures - ~75% implementation rate of the recommendations.



- *Integrated management systems*
- *Leadership and management for safety*
- *Organization oversight (safety committees)*
- *Quality of safety documents*
- *Safety of experiments and modifications*
- *Operational radiation protection*
- *Training programmes*
- *Operating procedures*

IAEA Assistance – Peer Reviews and Operational Safety

- More than 100 INSARR missions in more than 45 countries
- ~ 10/y advisory missions based on INSARR methodology.
- IAEA continues to enhance INSARR efficiency and effectiveness (guidelines, self-assessment, training, reporting).

Survey (2021) - Experts of 69 countries: 97% of responders highly regarded quality of preparatory support, conduct of the mission, recommendations, and reporting.

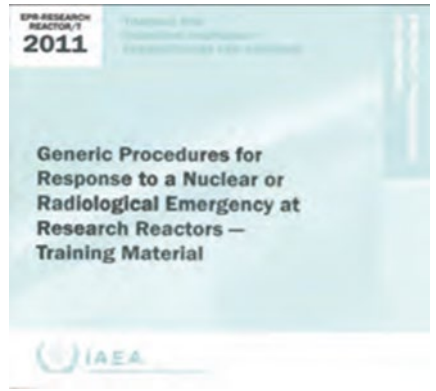
IAEA Assistance – Capacity Building

- **E&T and human resources development:**

•Training packages and online video presentations;

• ~10/ year workshops/meetings on topics of interest (management systems, ageing management, safety of experiments, digital I&C, use of AI, safety & security interface);

•New research reactors: E-learning (Internet Reactor Laboratory - IRL), regional reactor schools, and ICERR.



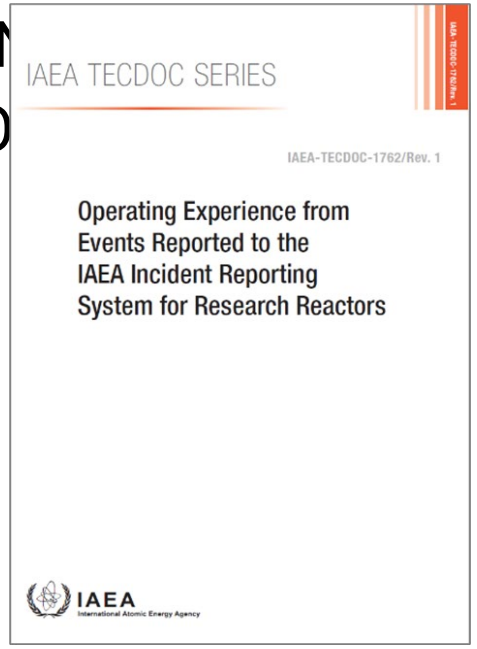

Group fellowships


IRL training

Survey (2021): *MSs reported tangible gains in knowledge and skills*

IAEA Assistance Networks and Operating Experience

- Operating international OEF system (all countries operate research reactors are IRSRR members).
- Information networks: GNSSN ANSN, ANNuR, FNRBA, FORO regional safety committees.
- Working group on safety of research reactors within ANNuR.



Conclusions

- Research reactors have a strong potential for contribution to socio-economic development. Effective partnership and cooperation help achieve this goal.
- Challenges remain to ensure safety. They are mainly related to organizational effectiveness, ageing of facilities, management of spent fuel and decommissioning, expansion of use of advanced technology and nuclear power, and relevant regulatory framework. *Addressing these challenges is indispensable for a sustainable future of the facilities*.
- IAEA has been (and will continue) assisting in addressing these challenges, including through support application of the Code of Conduct, development of safety standards and support their application through peer reviews, capacity building, and facilitation of regional and international cooperation.

IAEA

Thank You