# *Initiatives supporting Research Reactor Safety in the Asia-Pacific Region*

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7% growth according to UNESCAP


24 APPPC Member Countries
China
Korea DPR
Rep. of Korea
Paki-stan
Nepal
India
Myanmar
Bang-ladesh
Lao PDR
Viet Nam
Thailand
Cambodia
Philippines
Sri Lanka
Malaysia
Indonesia
Papua New Guinea
Solomon Islands
Samoa
Fiji
(France)
Tonga
Australia
New Zealand

- Increasing energy demand
- Nuclear Power included in energy policies
- Growing middle class
- Increased demand for health services, industrial products and growing scientific endeavour and capability
- Research Reactors will play a role

OPAL research reactor | Science, Health & Industry

Australian Government

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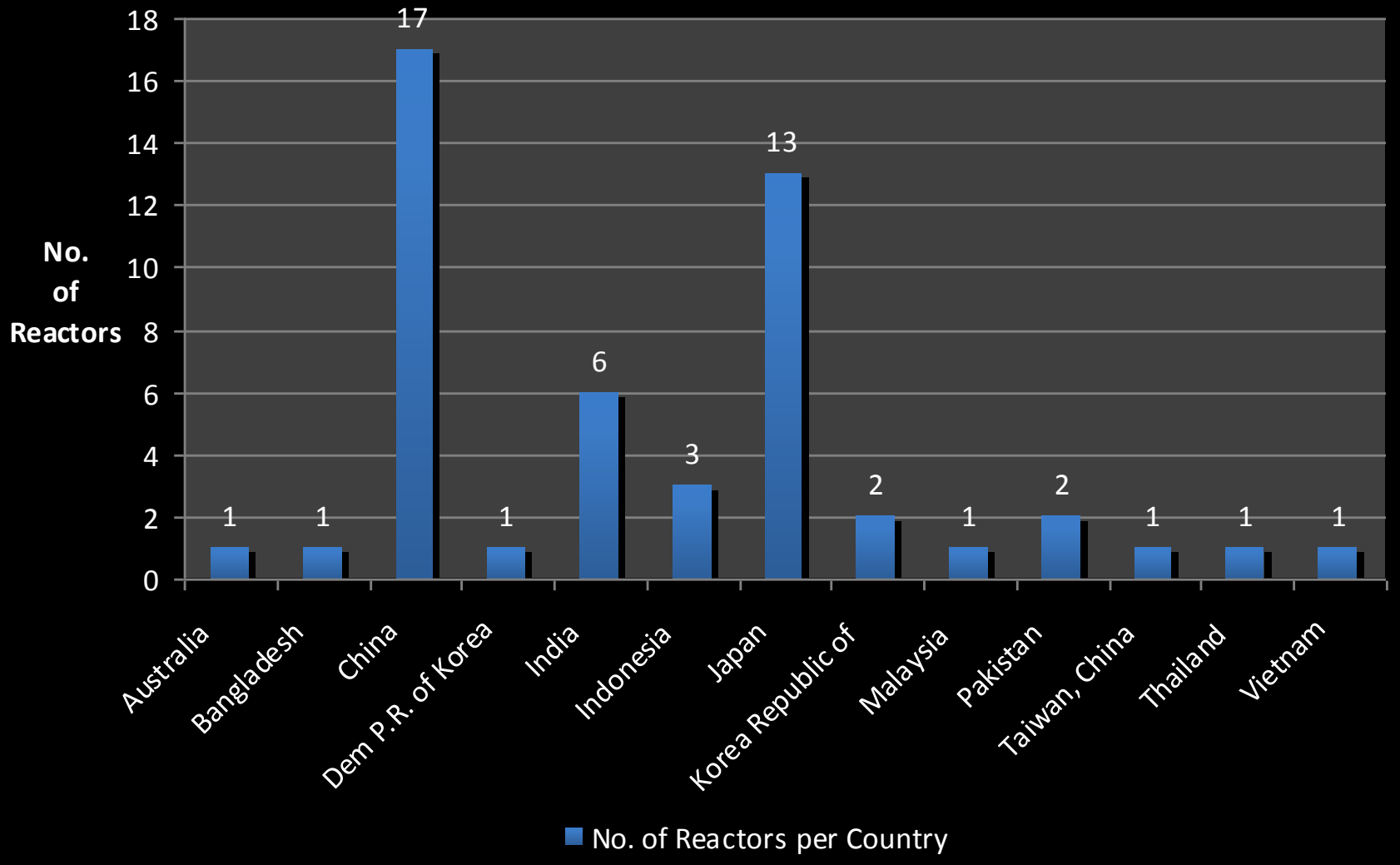
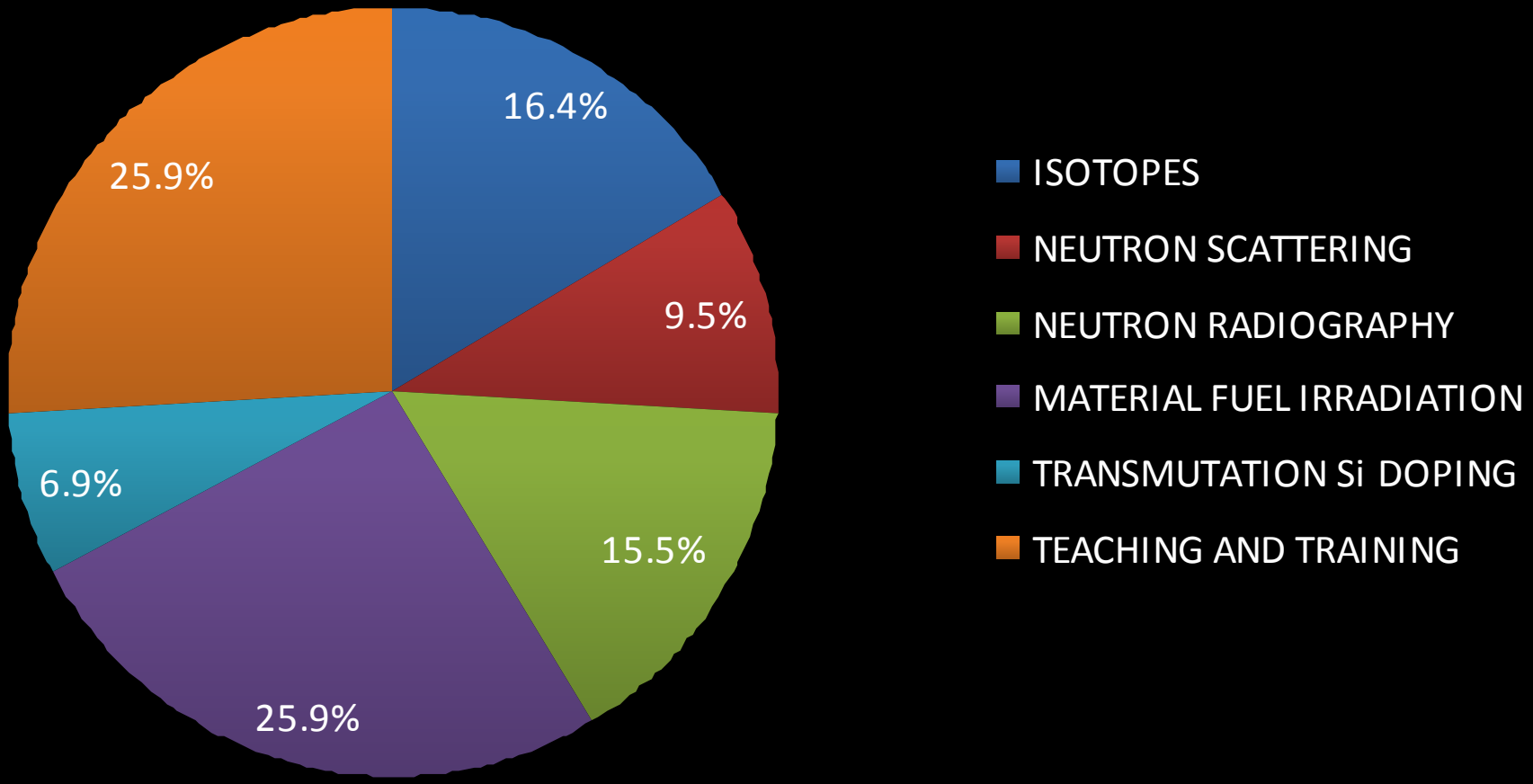
# Reactors in Operation



# Breakdown of Research Reactors Utilisation




Type of utilisation in the Asia-Pacific

Research reactors - traditional logical step to nuclear power

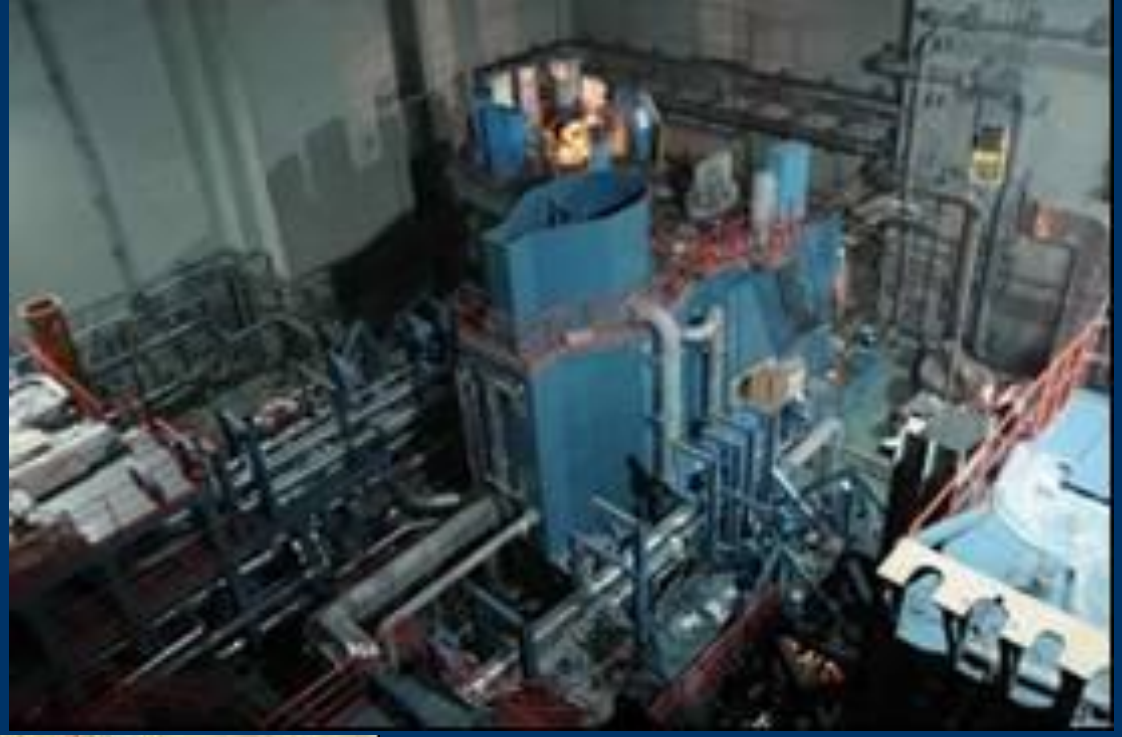
Test-beds for systems, training tools for people

New entrants in the Asia-Pacific

- Vietnam 8000 MWe by 2025
- Thailand – commence first construction in 2014
- Malaysia – decision in 2013

Increasing capacity in the Asia-Pacific

- China – 26 new NPPs
- Korea – 7 new NPPs by 2016



*Source: CIAE*


# China Experimental Fast Reactor

*Source: NRI, Dalat*

*Source: JAEA*

*Source: KAERI*

## Utilising existing research reactors

Diverse experimental and research reactors – variable facility design

Multi-purpose reactors – complex systems

Increasing utilisation – more operation time and new operational imperatives

Strong safety culture

System uniformity (where possible)

Excellent training & development

Uniform and transparent regulation

# China

In 2010 an agreement was reached between CIAE and Argonne National Laboratory (USA) to co-operate on the conversion of MNSR reactors to LEU fuel. Strong & uniform safety culture

# India

Following the Fukushima accidents the Government has moved to formally separate the AERB from the Department of Atomic Energy. A Bill has been tabled in Parliament and is currently being considered through the committee process.

# Japan

Stress tests have been introduced for Japanese research reactors following the Fukushima Daiichi NPP accidents. These analyses are ongoing

# Indonesia

BAPETEN has released a comprehensive approach to ageing management for research reactors and is incorporating ageing reviews into the re-licensing process using the mechanism of periodic safety reviews

# Korea

KAERI is developing the Advanced Nuclear Safety Information Management system to support management and retain staff knowledge in a systematic and efficient way. It will collect information from the facility and the people to support business processes and management, and provide statistics and trends on people

# Malaysia

The AELB is undertaking a program to strengthen the national nuclear regulatory infrastructure in preparation for the introduction of nuclear power. The AELB will also be undertaking the Building Regulatory Competency in Probabilistic Nuclear Safety Analysis project, and will become a member of the Global Nuclear Safety Network

# Thailand

The OAP's Bureau of Radiation Safety Regulation has been set up to perform radiation safety regulation and law enforcement, to carry out inspections, evaluation licensing and coordinating of matters related to radiation safety. They also coordinate with other organisations in Thailand and abroad on radiation emergency preparedness

# Vietnam

VARANS has made a significant investment in the development of people and processes over the last 5 years. Technical capability has increased with assessments being made of the Dalat Reactor included a license renewal application, and LEU reactor core conversion

# Australia

ARPANSA incorporate the principle of international best-practice in nuclear and radiation safety into their regulatory principles. This practice led to the imposition of a licence condition in 2006 on the OPAL research reactor, requiring that Periodic Safety Reviews be undertaken by ANSTO as a condition of reactor operation

Stop press – Uranium to be sold to India

# Building Capacity & Capability through exchange

Bi-lateral agreements

Networks

- ANSN
- FNCA

Co-operation agreements

Research Reactor Code of Conduct

# VIETNAM

***Radiation protection***: Multichannel area monitoring system

***Waste management***: Liquid waste evaporator system installed

***Physical security system***: Security system upgraded in 2008

***Decommissioning activities***: Planning for decommissioning of the Dalat reactor was carried out between 2009-2011

***Reactor instrumentation and control system***: Modification and replacement of the reactor control system between 2005-2008

***Core conversion***: The reactor start-up with LEU fuel - Dec 2011

***Recruitment, training and qualification of personnel***: A new process for recruitment, training and qualification

# CHINA

***Scope of reactors***: China has had a large number of research reactors significant variation in the technical capability, safety systems, and ageing

***Regulatory initiatives***: The safety of all the research reactors is regulated by the Bureau of Nuclear Safety.

The Bureau has established six nuclear and radiation safety stations across the country. The personnel in the stations have the responsibility to ensure that the operating organisation complies with,

- the safety design of the reactor;
- the approved quality system;
- license conditions,
- audit operators' capability in emergency planning and response.

Established The Centre for Nuclear and Radiation Safety as its primary arm of R&D activities and technological support with several branches in different parts of the country.

# INDIA

***Safety Reviews***: Periodic Safety Reviews conducted at 10 yearly intervals

***Ageing Management***: Systematic ageing studies were undertaken at the 40 MW Cirus research reactor - assisted with high availability operation for a further 10 years until the reactor was shut down in December 2010.

***In-Service Inspection***: A program was developed for Dhruva in line with the practice followed at NPPs

# REPUBLIC OF KOREA

- ***Legal and Regulatory framework***: The regulatory body separated from the Ministry Energy Science and Technology (MEST) in October 2011. The regulatory body has a plan for the formulation of specific rules for research reactors
- ***Safety Performance***: KAERI is voluntarily developing a Safety Performance Index for the HANARO reactor. This initiative will be introduced at the current IAEA conference.
- ***Emergency preparedness***: In response to the Fukushima accident, KAERI will prepare a Severe Accident Manual for the HANARO reactor
- ***Ageing management***: KAERI has commenced work for an ageing management program at HANARO. The regulatory body and KAERI are discussing the formulation of a Periodic Safety Review system for research reactors in Korea.
- ***Safety culture***: KAERI has been undertaking a variety of activities to promote safety culture, including regular seminars and peer reviews. Safety culture surveys have been carried out every two years since 2006 to measure the level of improvement.
- ***External events***: A reevaluation of flooding effects under extreme weather condition and a stress test of the reactor building and stack was ordered. KAERI will complete the reevaluation in 2012.

# AUSTRALIA

- ***Periodic Safety Review***: The first PSR report for the 20MW OPAL research reactor is in the final stages of review and is due to be submitted to the regulator by the end of November 2011.

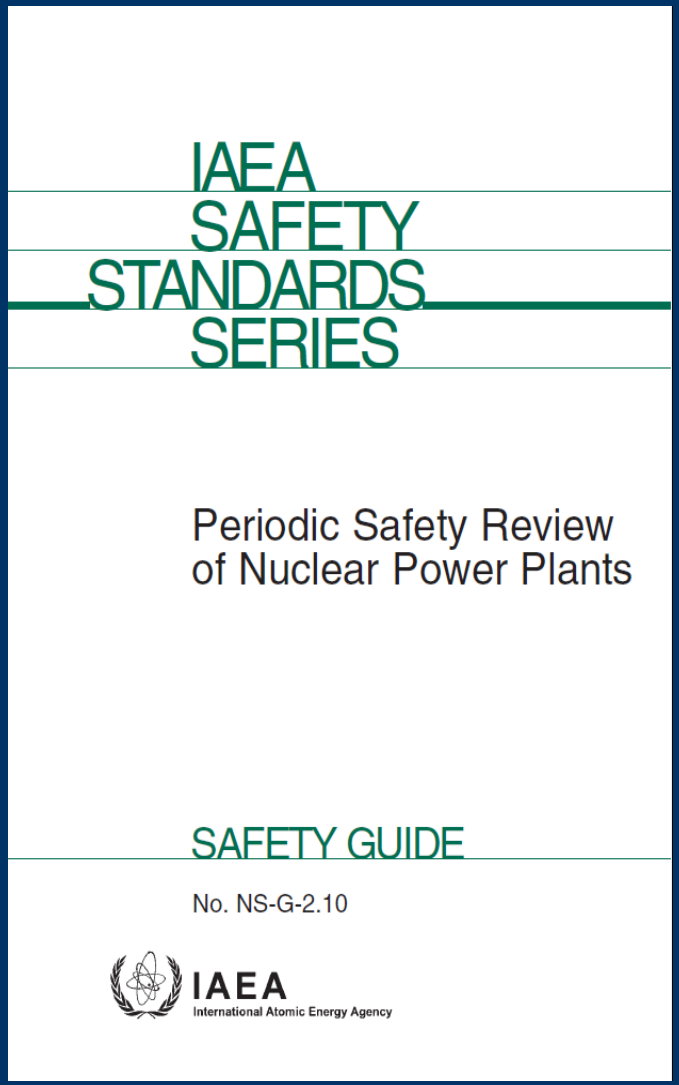
- ***Fuel fault and recovery program***: Following a fault with reactor fuel in 2007, a fuel re-design and restart program was instituted and the reactor restarted successfully 10 months later

- ***Asset Management***: A modern engineering asset management program commenced in 2010

- ***Decommissioning***: In 2010 ANSTO successfully completed the decommissioning of the 100kW MOATA research reactor. The project won a national award as a model engineering project.

- ***Co-operation agreements***: Formal co-operation agreement between OPAL, SAFARI1 (South Africa) and HFR (The Netherlands), and the staff exchanges with CEA (France).

- Special Licence Conditions
- Periodic Safety Review
- Using NPP guide
- International peer review
- Every 10 years
- Periodic Security Review as well



*Plant*

(1) Plant design
(2) Actual condition of SSCs
(3) Equipment qualification
(4) Ageing

*Safety analysis*

(5) Deterministic safety analysis
(6) Probabilistic safety analysis
(7) Hazard analysis

*Performance and feedback of experience*

(8) Safety performance
(9) Use of experience from other plants and research findings
(10) Organization and administration
(11) Procedures
(12) The human factor
(13) Emergency planning

*Environment*

(14) Radiological impact on the environment

*Global assessment*

# Regional Challenges

## *Safety*

- Worthy goal - “best-practice” in nuclear and radiation safety
- Research reactors and the community are diverse
- Strengths - range of applications

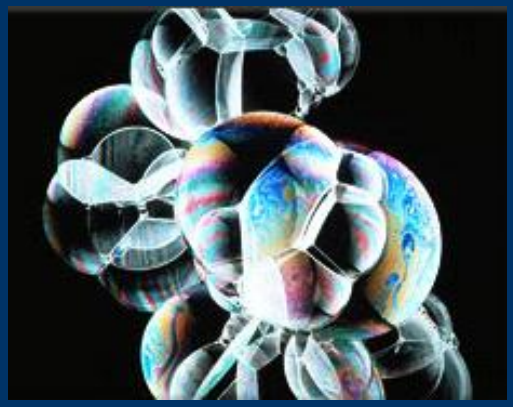
# Studies of Bulk Nanostructure

## Polymers and Industrial Emulsions

Materials used in countless industrial preparations are based on molecular nano-composites

Stabilised Polymer Emulsions

Scattering contrast between H and D allows components to be highlighted.



Surfactants

Conducting Polymers and Liquid Crystals



# Manufacture of radiopharmaceuticals

OPAL research reactor | Silicon irradiation

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# Regional Challenges

## *Safety*

- Weaknesses - level of safety, level of utilisation
- Achievement of good practice - a journey - realistic objectives, measurable indicators for performance, tangible outcomes
- Safety events, large & small, internal & external - use as focal points to assist in improvement.

# A black swan day - The external nuclear environment

# Regional Challenges

## *Safety*

- Fukushima accidents - regional consequences are particularly important because of regional nuclear power developments
- Challenge for RR safety - adaption to the international consensus in safety guidance that develops from the analyses post-Fukushima

# Regional Challenges

## *Ageing Management*

- The resources and systems for asset and ageing management are being developed and implemented in some nations
- The Challenge - ageing management issues will be amplified as utilisation levels of existing reactors increases, and as new reactors come on line.

## *Design Improvements*

- As reactors age and missions change a robust system for engineering modifications and design improvements will be required
- The Challenge - existing reactors will need to meet more rigorous and demanding standards and expectations

# Regional Challenges

## *The development of people*

- As nuclear capacity and capability grows there will be pressure on educational and nuclear institutions to develop effective programs for the development of people in nuclear
- The Challenge – the provision of effective programs to meet demand

## *The Life Cycle*

- Recognition that safety and protection of the environment is necessary well after RR operation ceases
- The Challenge - long-term planning and financing to support the management of radioactive wastes into the future

# The Future

The Asia-Pacific region is the growth centre for the world

It will be incumbent upon those nations that have nuclear capacity to use nuclear technology safely

The challenges will be significant especially through the lens of the events at Fukushima

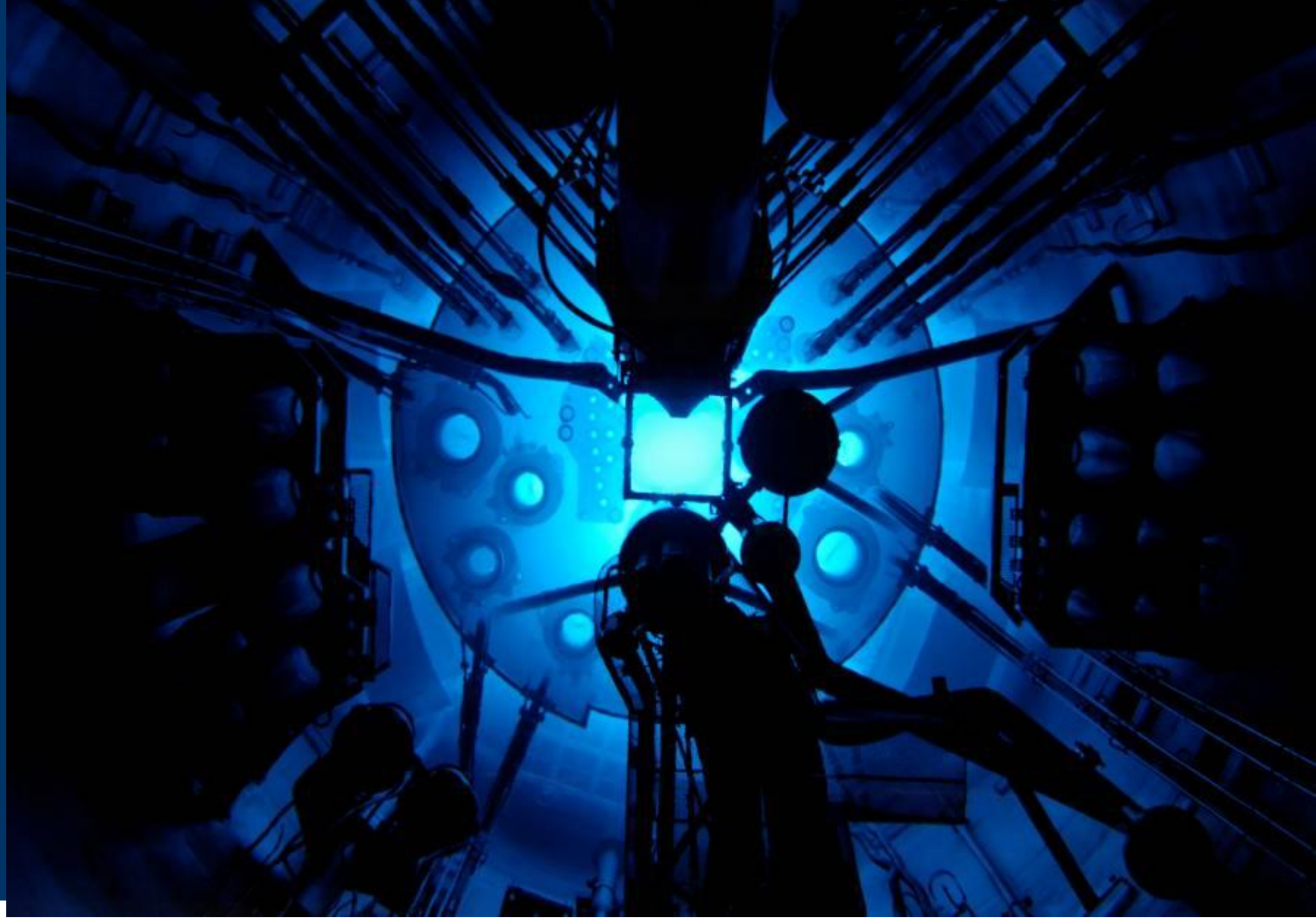
The research reactor code of conduct and effective networking , co-operation and collaboration will help in overcoming the challenges assist with a safe nuclear future

- China – Luzheng Yuan (CIAE)
- Korea – Hoan Sung Jung, In-Choel Lim - (KAERI)
- Vietnam – Nhi Dien Nguyen,
  - Cien Cuong Nguyen – (NRI, Dalat)
- India – D.K. Shukla, N. Ramamoorthy - (BARC), R. Gujarathi (AERB)
- Australia – Kylie Kwong, Julie Sprake,
  - Weijian Lu - (ANSTO)

Acknowledgements

*Source: UN*


QANTAS
A380

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