An Overview of Research Reactors
by IGORR forum
(International Group On Research Reactors)

Dr Gilles BIGNAN (IGORR Chairman)

French Atomic and Alternatives Energies Commission

Contact: gilles.bignan@cea.fr

OECD/NEA-Workshop NI 2050
7th-8th July 2015
A mature organisation who started in 1990

Motivations at that time:

“Many organizations, in several countries, are planning or implementing new or upgraded research reactors, but there has been no organized forum devoted entirely to discussions and exchange of information in this field”

(Extract from the charter of IGORR)

The International Group on Research Reactors (IGORR) was formed to facilitate the sharing of knowledge and experience among those institutions and individuals who are actively working to design, build and promote new research reactors or to make significant upgrades to existing facilities.

(Proceedings of the first meeting, 1990)

In 2015, Objectives and Motivations are the same: Sharing experiences on Operation, Experimentation, Safety, Refurbishment, new Projects…on any type of Research Reactors
**REMINDER:**

THE DIFFERENT FAMILIES OF RESEARCH REACTORS

**Neutron Beam Reactors**
- High neutron fluxes are probing matter and help establish fundamental laws
- Basic science
- Neutron radiography
- Production of radioisotopes

**Material Testing Reactors**
- R&D in nuclear engineering (materials and fuel)
- Production of radioisotopes (Molybdenum)

**Zero Power Reactor (or Critical assemblies)**
- Core physics
- Criticality and safety issues

**Reactors dedicated to Safety Research Programs**

**Reactors for Education and Training**
HOW DOES IGORR FORUM WORK?

- A conference is organised every 18 months (in average) since 1990
- A rotate location of the conference between Europe, Asia, Oceania and the Americas
- An International Steering Committee to establish the future conference and prepare the program (papers reviewing, organisation...)
- A strong wish from the SC to combine IGORR conference with other forums, such as:
  - Combined IGORR/US-TRTR (Oak-Ridge 2010)
  - Combined IGORR/RRFM (Prague 2012) and next one in Berlin (2016)
  - Combined with IAEA Technical Meetings (Daejeon 2013 on Ageing Management and Bariloche 2014 on Low Power RR)
- IGORR has no particular structure

→ strong involvement of the local organiser
AUSTRALIA: Mark Summerfield (ANSTO)
AUSTRIA: Danas Ridikas (IAEA)
ARGENTINA: José Lolich (Institute Balseiro), Juan-Pablo Ordonez (INVAP)
BELGIUM: Edgar Koonen (SCK.CEN)
CANADA: Christopher Haysel (Mac Master University)
CHINA: Ke Guotu (CIAE), Xinxin Lu (INET)
FRANCE: Gilles Bignan - Chairman (CEA), Claude Pascal (AREVA-TA)
GERMANY: Heiko Gerstenberg (TUM)
JAPAN: Takeshi Maruo (JAERA)
SOUTH KOREA: Hoan-Sung Jung (KAERI)
USA: John Bumgardner (INL), Doug Selby (ORNL), Rob Williams (NIST),
     Lin-Wen Hu (MIT), Hayman Hawari (NCSU)
RUSSIA: (Kir Konoplev-PNPI-retired -under replacement)

→ A panel representative of a large scope of activities in RR world
Refurbishment, Upgrade of Existing Research Reactors

Ageing Management

Operation & Maintenance

Utilization/Applications of Research Reactors

Safety Analysis (Reassessment, Refurbishment work, Complementary Safety Assessment following Fukushima accident...)

Innovative methods in Research Reactor Physics

Radio-Isotopes Production & Irradiation Services

New project of Research Reactors
IGORR 16 in Bariloche, Argentina (November 2014)
IGORR 15 in Daejeon, South Korea (October 2013)
IGORR 14 in Prague, Czech Republic (March 2012)
IGORR 13 in Knoxville, USA (September 2010)
IGORR 12 in Beijing, China (October 2009)
IGORR 11 in Lyon, France (March 2007)
IGORR 10 in Washington, USA (September 2005)
IGORR 9 in Sydney, Australia (March 2003)
IGORR 8 in Munich, Germany (April 2001)
IGORR 7 in Bariloche, Argentina (October 1999)
IGORR 6 in Daejeon, South Korea (May 1998)
IGORR 5 in Aix-en-Provence, France (November 1996)
IGORR 4 in Gatlinburg, USA (May 1995)
IGORR 3 in Ibaraki, Japan (September 1993)
IGORR 2 in Saclay, France (May 1992)
IGORR 1 in Knoxville, USA (February 1990)

Proceedings available on the IGORR website www.igorr.com
TOTAL number of RR: 737

Operational: 246
Temp. shutdown: 20
Under construction: 3
Planned: 8
Shutdown: 148
Decommissioned: 306
Cancelled: 6

Since 1985, ~2 times more shutdown RRs than newly commissioned

http://nucleus.iaea.org/RRDB/
A LARGE MAJORITY OF LOW POWER RR (IAEA DATA)

TOTAL number of RR: 737

- Operational: 246
- Temp. shutdown: 20
- Under construction: 3
- Planned: 8
- Shutdown: 148
- Decommissioned: 306
- Cancelled: 6

- Low Power RRs including Zero Power RR (<~ 1 MW) represent about 80% of the fleet
- Medium Power RRs (1 MW-20 MW) represent about 15% of the fleet
- High Power RRs (above 20 MW) represent about only 5% of the fleet
  - Neutron beam RR: ILL, FRM2, HFIR, HANARO…
  - Material Testing Reactors: BR2, HFR, OSIRIS, ATR...

http://nucleus.iaea.org/RRDB/
Number of operational RR is decreasing and more than 50% of RRs remain fully underutilized

Ageing, including staff, need constant modernization/refurbishment and Human Resources challenges: major issue!

Often absence of clear utilization purpose & strategy: IAEA is promoting the establishment of Strategic Plan with identified Stakeholders before embarking on a new RR

Recent IAEA Initiative on ICERR

Requests by “newcomers” to assist in the first RR project: Jordan, Kuwait, Saudi Arabia, Sudan, Tanzania, Tunisia, Bolivia, Azerbaijan, Mongolia...
TODAY’S TENDENCY: A SAFETY ENHANCEMENT LEADING TO RATIONALIZATION OF THE RR FLEET

- Regular safety re-assessment has to take into account updated requirements (seismic risks, fire risks, human factor error, post-Fukushima stress tests…)

- Refurbishment or shut-down of existing reactors after a cost/benefit analysis → Rationalization of the Fleet

- New tendency: Construction of new facilities in the framework of international partnerships for cost sharing and/or construction of dedicated RR “Market Oriented”

\[
egin{align*}
\text{SAFETY LEVEL} \\
\text{Upgrading of the safety} \\
\text{Performances of the installation towards the safety} \\
\text{Degradation forbidden} \\
\text{Upgrading of the safety or decision of stopping activity} \\
\text{Requirements of Regulations} \\
\text{TIME}
\end{align*}
\]
EXAMPLE FOR FRANCE:
35 RESEARCH REACTORS BUILT FROM 1948 UP TO 1980
8 RR IN OPERATION IN 2015

All the French RR are owned and managed by CEA
Except HFR managed by the Laue-Langevin Institute (ILL)-(France/Germany/Great-Britain association)
Some Outcomes from the last IGORR 2014 Conference combined with IAEA Technical Meeting on Low Power RR
OUTCOMES FROM LAST IGORR CONFERENCE

Safety:
- Positive trend was observed for research reactors in operation who performed periodic safety review (good practice recommended by the IAEA code of Conduct)
- Consideration of the Fukushima-Daichi accident is taken into account for Periodic Safety Review both for RR in Operation and new projects

Operation & Maintenance:
- Innovative methods to execute maintenance inspections are developed and encouraged by the SC (example: optimisation of radiological conditions for the inspections)
Ageing Management

- Change of Reflector at OSU (Oregon State University) and OSIRIS (CEA) component tests using pool divers (with strict control of the dosimetry) were significant experiences valuable for the RR community (IGORR SC proposed to input these experiences into the ageing data base of the IAEA)

Fuel

- Modelling and numerical simulations have an increased importance as demonstrated by the papers on atomistic simulation of the inter-diffusion layer, 3D simulation of behaviour of the irradiation and modelling of the co-rolling process
Innovative Methods:

- Core physics: trend to use Monte-Carlo code with depletion methods
- Trend to better address uncertainties issue
- Combined calculation-instrumentation for enhancing research reactor core management
Utilisation:

- Utilisation of low and medium power RR shows a very large panel of achievement for E&T, RI production, neutron beam research.

- Special focus was on the application of CNS (Cold Neutron Source) for neutron beam RR which are of primary importance for the scientists.

- Important message: Research reactors are flexible tools and each owner should have the capacity to respond to changing utilisation needs during lifetime of the RR, such as:
  - HFIR (ORNL) shift from RI production to neutron beam research.
  - ISIS (CEA) shift from MTR mock-up to Education & Training and becoming an IAEA IRL (Internet Reactor Laboratory).
New Research Reactors

Several Research Reactors are under different stages of implementation (from feasibility studies to construction):

- **France**: JHR (*Material Testing Reactor*) 100 MW
- **Russia**: MBIR (*Sodium cooled RR*) 100 MW
- **Jordan**: JRTR (*neutron beams and RI production*) 5 MW
- **Korea**: KJRR (*dedicated to RI production and NTD*) 15 MW
- **Argentina**: RA-10 (*neutron beams and RI production*) 15 MW
- **Brazil**: RMB (similar to RA-10)
- **South-Africa**: SAFARI-2 (*neutron beams and RI production*)
- **Belgium**: MYRRHA (*Pb-Bi coolant RR-ADS*) 100 MW
- **Netherland**: PALLAS (*RI production-MTR*) ~ 50 MW

IGORR SC noticed a trend to optimise the utilisation of future research reactor (feasibility studies and strategic plan)
In summary An active Research Reactors Community ! Thank you