Shared Use of Research Reactors for Infrastructure Development

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Role of RRs in the development of a NP programme

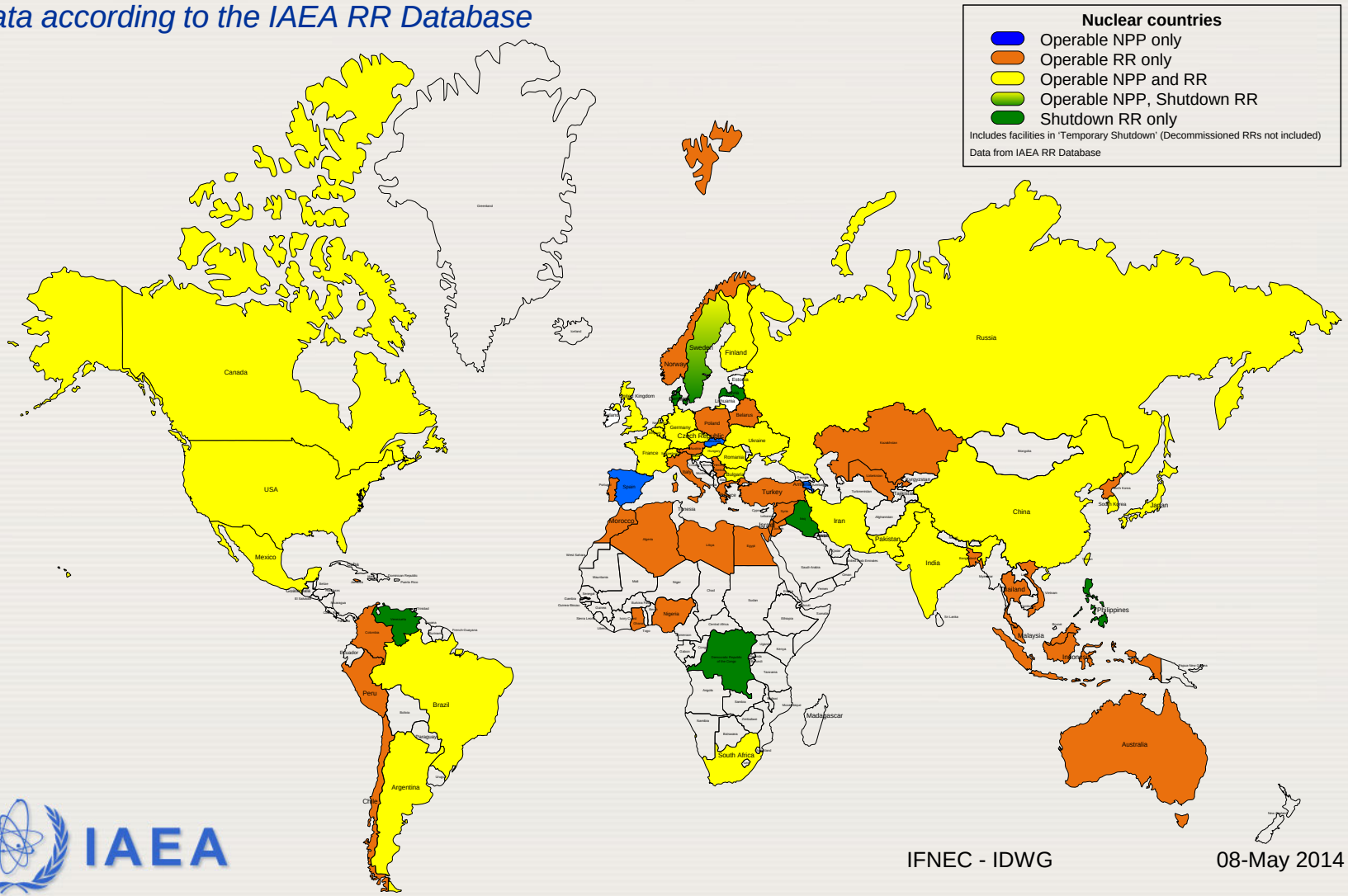
Summary

- Overview
- Research reactors in NPI development
- Use of research reactors in NP staff training and education
- Conclusions

Overview

- **266** operating or temporary shutdown RRs in **56** IAEA Member States

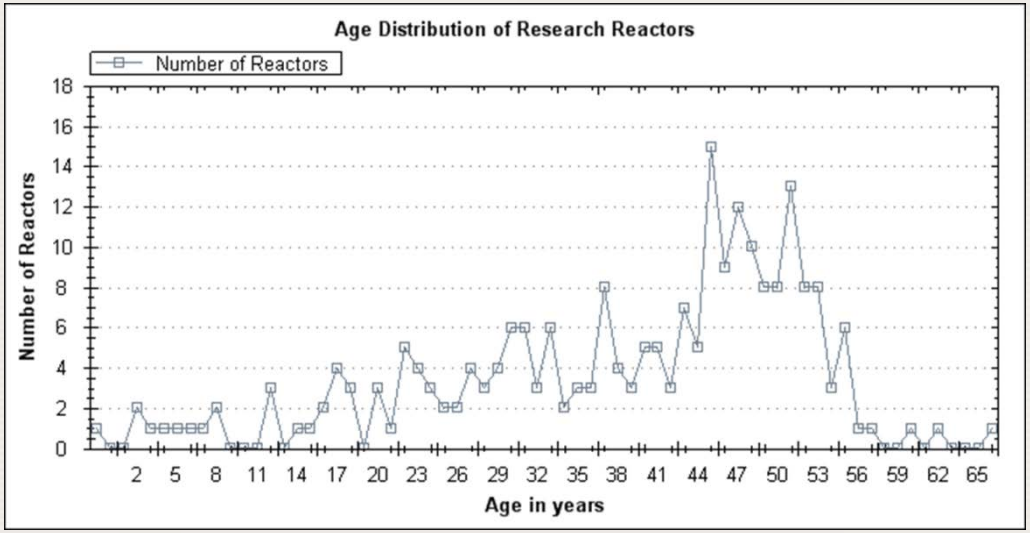
Data according to the IAEA RR Database

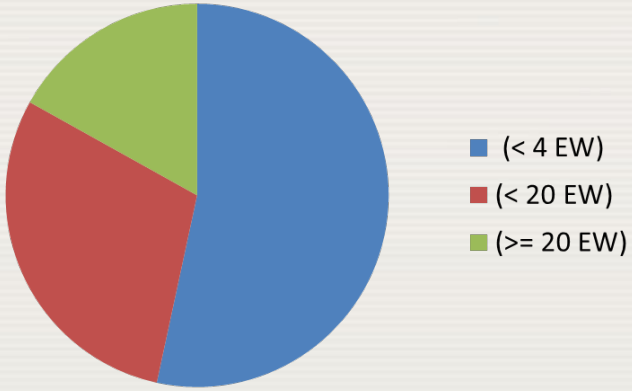


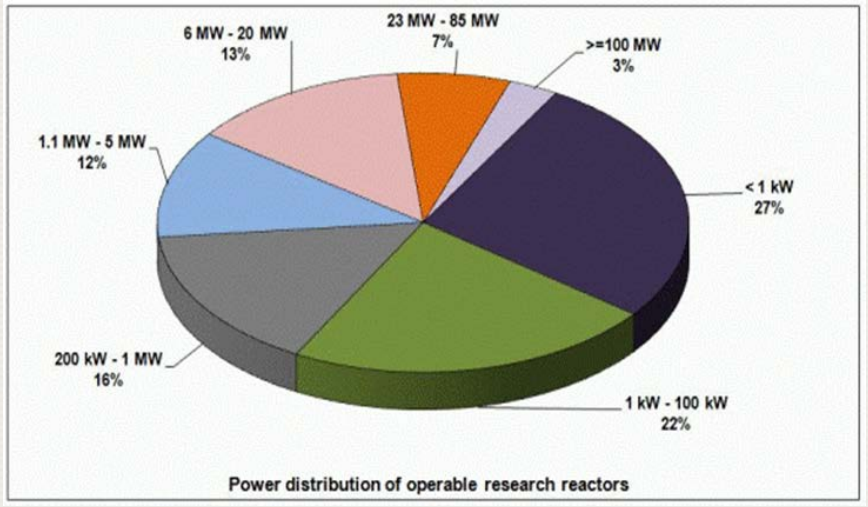
Overview

Diversity of

- Age (58% > 40y)
- Power level / flux
- Application
- Utilization
- Design
- Fuel type
- Organizational size, structure and ‘context’
- Funding mechanism.







Overview

Application	Number of RR involved	Involved / Operational, %	Number of countries
Education & Training	161	67	51
Neutron Activation Analysis	122	51	54
Radioisotope production	90	37	44
Neutron radiography	68	28	40
Material/fuel testing/irradiations	60	25	25
Neutron scattering	48	21	32
Nuclear Data Measurements	42	18	20
Gem coloration	36	15	22
Si doping	35	15	22
Geochronology	26	11	21
Neutron Therapy	20	8	13
Other	95	40	29

Role of RR in NPI development

- Is an RR needed for NP infrastructure? Is it useful? Is it justified as a first step to nuclear power?
- Is having an RR an asset or a liability for NPI development?
  - Safely & reliably operated? Well maintained? Heavily utilised? Adequately funded?
- Experience shows that support for NP is not, in itself, enough to justify an RR.
- >50% of 246 operational RRs worldwide are underutilised (<4 full-power weeks/yr.).

Role of RR in NPI development

2010 – 2012

- Internal discussions regarding role of RR in an NPP programme

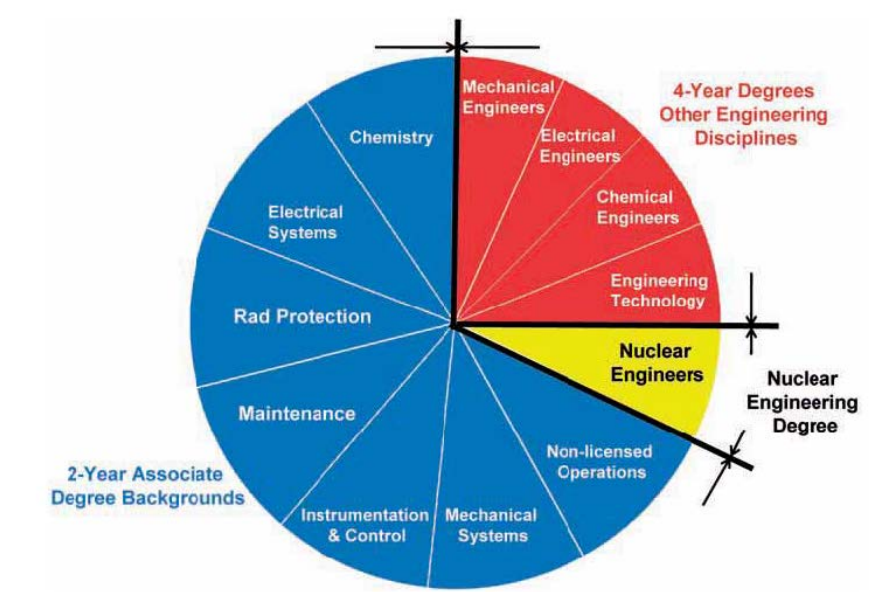
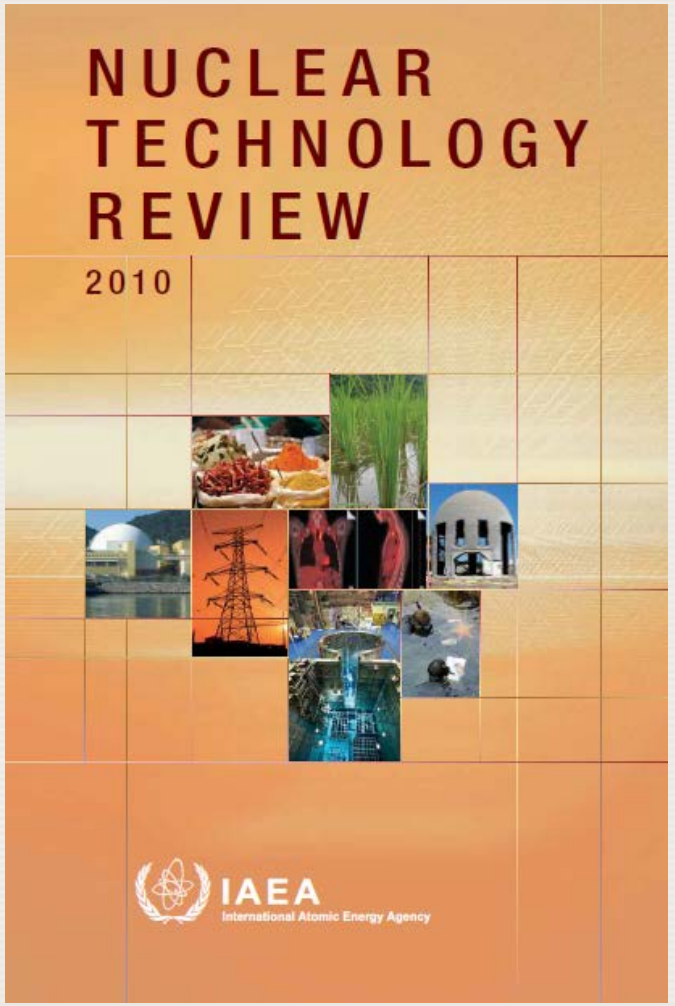


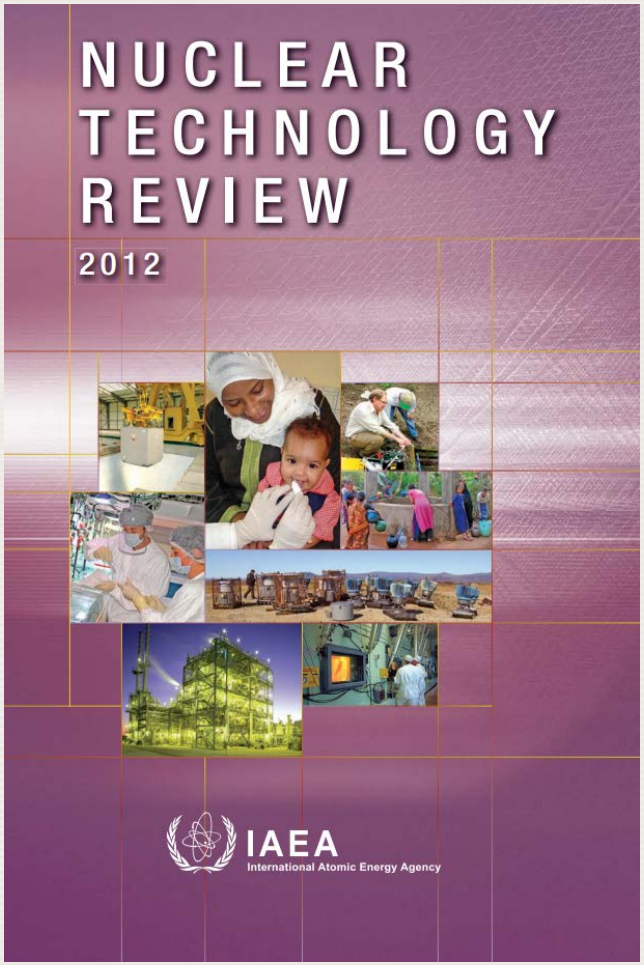
FIG. V–8. Example of distribution of disciplines for the nuclear workforce.



Role of RR in NPI development

2012 NTR – Annex

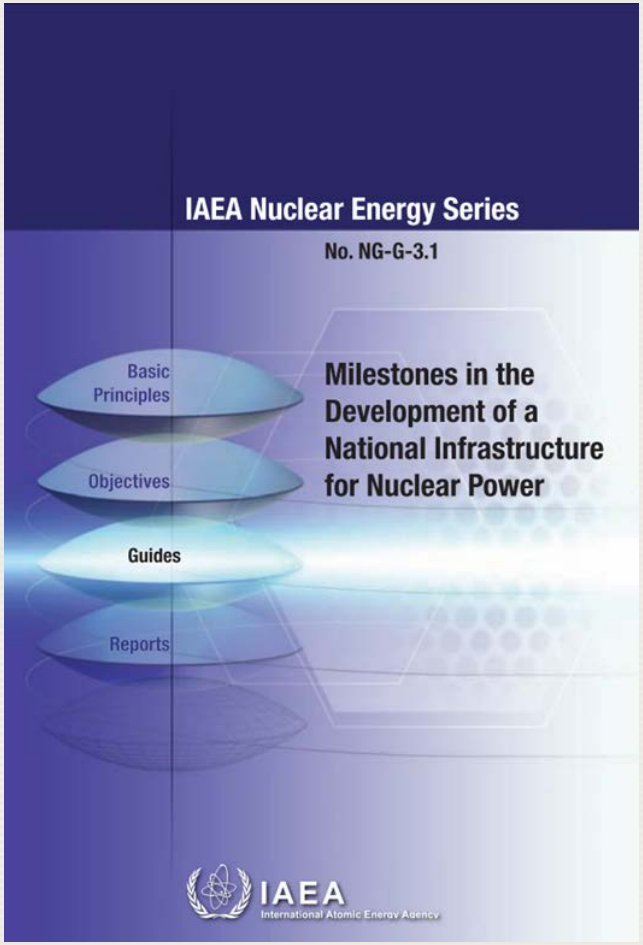
- Discussed relevance of a RR programme to select Issues within the Milestones approach.
- Highly dependent on the type of RR, other applications, demonstrated facility culture(s)
  - safety,
  - quality,
  - operational performance,
  - etc.



Role of RR in NPI development

2012 Meetings (April Consultancy & December Technical Meeting)

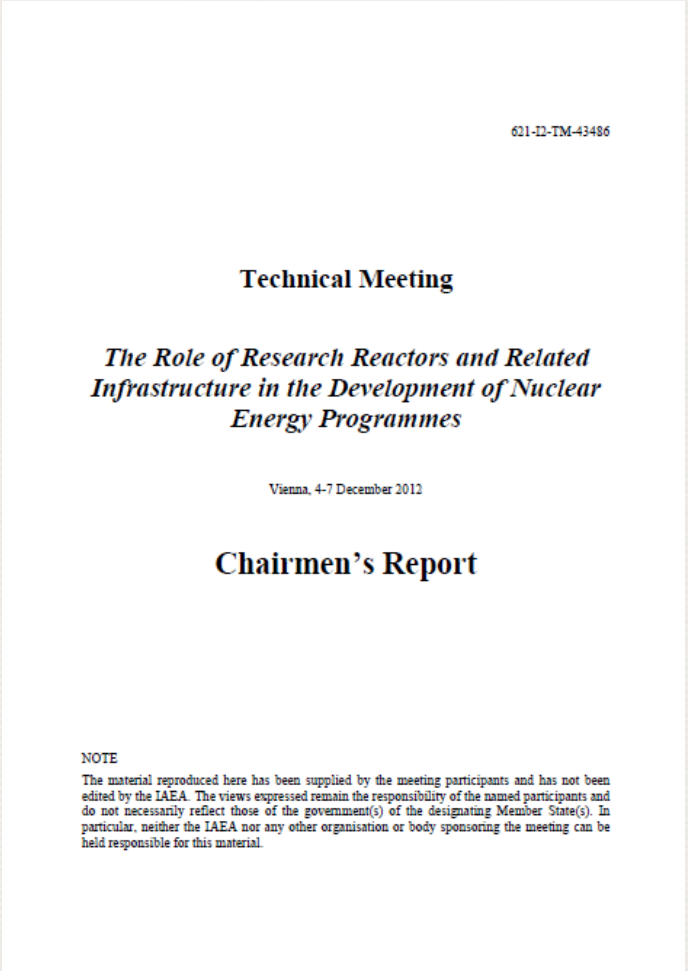
- Purpose: identify role and limitations of RRs in the development of nuclear power infrastructure
- 3 Expert consultants with both RR and Nuclear Power Industry experience.
- 27 Participants from 19 Member States representing RRs, Government and NPP utilities.
- Representation also **balanced** between countries with mature (large and small) nuclear power programmes and embarking countries.



Role of RR in NPI development

Participants agreed a well-managed RR programme could potentially assist an embarking country with

- 17 of the 19 issues; Issues 4 – Funding and Financing, and 9 Electrical Grid being the exceptions
- The potential contribution depends heavily on
  - RR power level and application
  - specific capabilities
  - demonstrated good operational and safety performance,
  - whether the RR organisation has earned the trust of national and potentially international stakeholders,
  - the age of the RR and
  - experience of the staff.



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Technical Meeting

The Role of Research Reactors and Related Infrastructure in the Development of Nuclear Energy Programmes

Vienna, 4-7 December 2012

Chairmen's Report

NOTE

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Role of RR in NPI development

Power level	E&T	NAA	Isotope production	Transmutation effects			Neutron imaging (2)	Neutron scattering (2)	BNCT (2)	Testing		
				Silicon Doping (3)	Gamma irradiation	Gemstone Coloring (3)				I&C	Materials (3)	Fuels (3)
<1kW	F	S								S		
100kW	F	F	S		S		S	S	F	S		
1MW	F	F	S	S	S	S	S	S	F	F	S	
10MW	F*	F	F	F	F	F	F	F	F	F	F	S
>10MW	F*	F	F	F	F	F	F	F	F	F	F	F
Time required, years	0.5-1	2-3	0.5-5	3-5	0.5	2	2-4	3-10	5	0.5	3-5	3-10
Investment costs, US $k	5-80	150-300	50-5000	200-1000	10	100-500	150 – 1000	>1000*	2000-5000	1-20	>2000	>5000
Staff required	1-3	2	2-20	2-6	1	1-2	2-3	2-3*	2-3**	1	2-10	5-20

S Some capability (e.g. R&D or demonstration capability)

F Full capability (e.g. capable in commercial production)

(1) Requires fully thermalized neutrons.

(2) Requires a beam tube.

(3) Requires a loop or special irradiation facility.

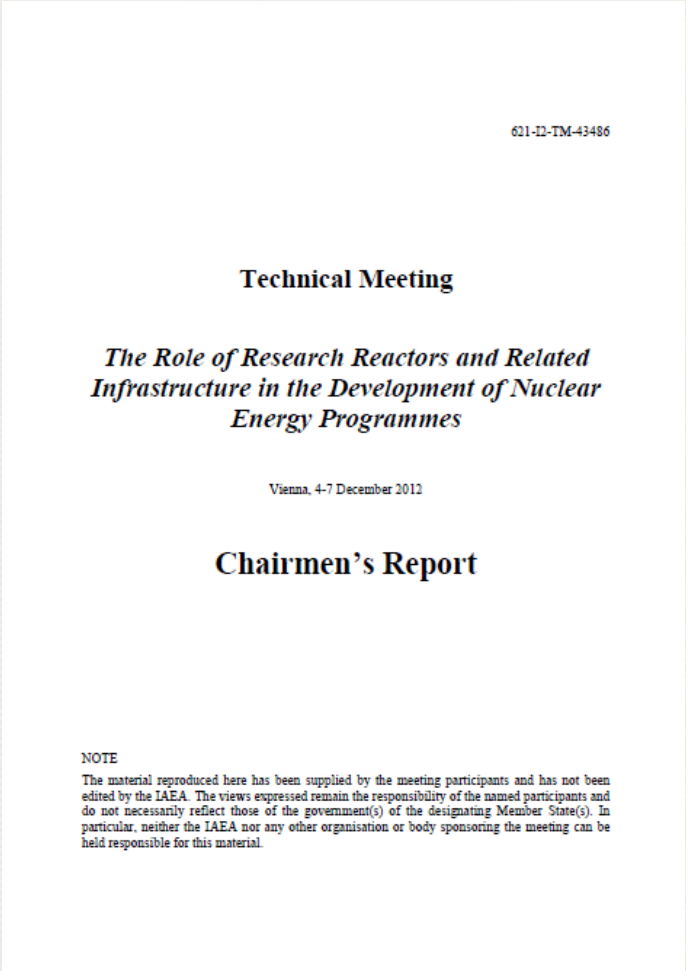
Time required for completion and implementation
Investment costs for completion and implementation
Staff required for operation (in addition to reactor operation team)

*** Dec 2012 TM – Higher powered RRs not typically used for E&T due to conflict with other applications.**

Role of RR in NPI development

Participants agreed that, in general

- Main contribution will be during Phase 1, when the country is developing a general understanding of the implications of a NP programme
- An RR may contribute to Phase 2, when a country is building the infrastructure and getting ready to sign the contract particularly for
  - safeguards,
  - radiation protection,
  - nuclear safety,
  - waste management, and
  - regulatory framework.
- Experienced RR staff may serve in an advisory role or, in some cases, become part of the nuclear workforce.



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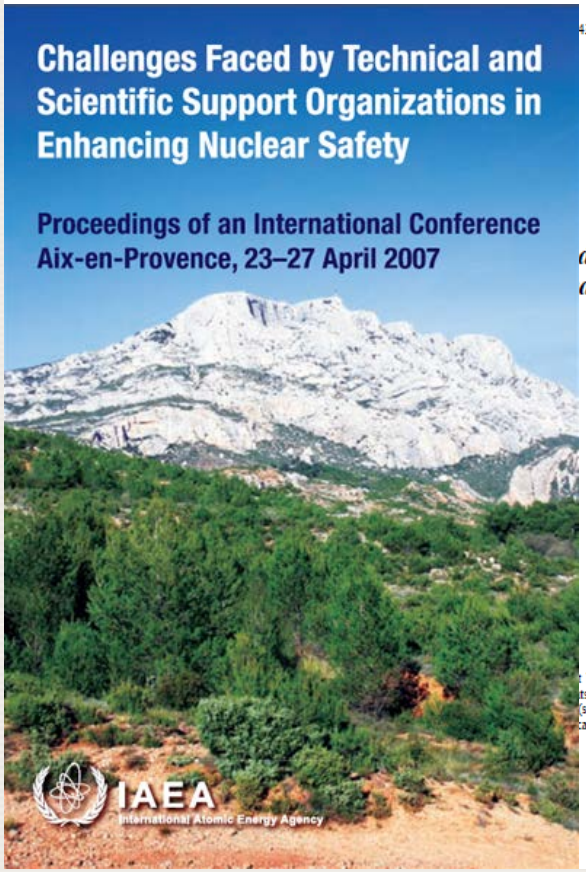
Role of RR in NPI development

Participants agreed that, in general

- In countries with small nuclear power programmes the technical support organisation (TSO) has often been built around the RR and its expert support included:
- NPP power upgrade studies,
- life extension analyses and
- expert advice to the utility or the regulatory authority.



RR use in NP staff training and education

- For some countries an existing RR is a useful tool for training and education:
  - understanding of applied physics and nuclear engineering,
  - practical exercises on an operating reactor (criticality, rod worth determination, coefficients of reactivity),
  - experience of facility operation and maintenance (safety, radiation protection and waste management)
- Countries without an RR may still access the capabilities by:
  - joining an RR coalition and benefit from direct access to an RR.
    - Participation welcome even without a reactor.
  - establish a remote reactor project in cooperation with an RR.

RR use in NP staff training and education

Country – Research Reactor	Number of staff trained			
	2008	2009	2010	2011
Austria*, TRIGA Mark II, 250 kW	15	15	15	8
Brazil, IPEN/MB-01, 0.1 kW	0	23	0	37
Czech Republic**, VR-1, 5 kW	13	31	51	33
France, ISIS reactor***, 700 kW	290 (i=11%)	310 (i=17%)	350 (i=32%)	400 (i=30%)
France, MINERVE, 0.1 kW	40	40	40	60
Germany****, AKR-2, 0.002 kW	41	50	44	25
Italy, TRIGA Mark II, 250 kW	0	47	47	24
Malaysia, TRIGA Mark II, 1000 kW	20 +	-	10 ++	-
Slovenia, TRIGA Mark II, 250 kW	51	41	32	70

* For utilities in Slovakia

** For utilities in the Czech Republic and Slovakia

*** Depending on the specific objectives, training course durations range from 3 to 24 hours (i = percentage of international students)

**** For 9 other countries

\+ 17 engineers from a utility, 3 lecturers from a university

++ All lecturers from a university

RR use in NP staff training and education

- **PUI** project on the application of RRs to nuclear capacity building
- US provided PUI funding in 2011
- France committed to provide in-kind equipment and training 2014
  - **EERRI** Group Fellowship (59 trained since 2009)
    - Expanding to Asia-Pacific
  - **Internet Reactor Laboratory** (Demonstrated between USA and Jordan in 2010)
    - Expanding to Lain American, Europe and North Africa
  - **Compendium** of RR exercises and experiments related the application of RRs to education and training

Conclusions

- Nuclear research and education infrastructure played an important role in the historical development of NP infrastructure
- Future role may depend on:
  - the specific expertise and experience (technical and other) that the RR Infrastructure can offer;
  - choices of national participation and technology transfer;
  - the comparative advantage offered by RRs as opposed to other options;
  - the availability of required services & expertise (indigenous or via networking).

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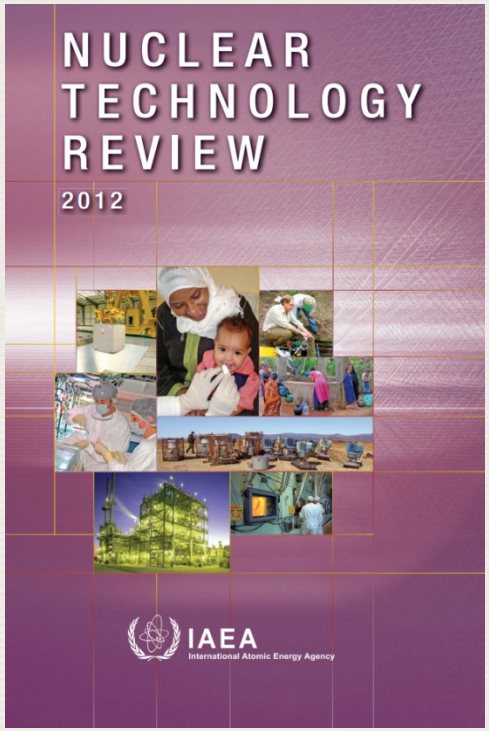
- IAEA, Challenges for Research Reactors - Interview with Danas Ridikas

Thank You

RR & Related Infrastructure

For the purposes of this presentation

- Research Reactor (RR) – the reactor, support facilities and staff.
- Related Infrastructure
  - Treaties, frameworks and conventions
  - Nuclear legislation, regulations and independent regulator
  - Emergency preparedness and an emergency response organisation
  - Waste management (facilities, logistics, expertise)
  - TSO
  - Nuclear technology related education programmes
  - Intangibles (experience, ‘culture’, attitude)



Role of RR in NPI development

- Historically, all nuclear power programmes developed from an initial RR & indigenous scientific capability
- Currently UAE is taking a direct approach to NP.

- New RR projects
  - ARG – 30 MWt multipurpose
  - BRA – 30 MWt, multipurpose
  - FRA – 30 to 100 MWt MTR+
  - JOR – 5-10 MWt, multipurpose including support of NP programme
  - JOR – Sub-critical assembly, hands on training
  - KOR – 20 MWt, multipurpose
  - NLD – 30 to 80 MWt Isotope production+