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Working Material

Report of the IAEA Consultancy Meeting on

Regional Research Reactor Coalitions and Centres of Excellence to Enhance Availability, Utilization and Support to Newcomer States Planning Nuclear Power Plants

13 - 16 October 2010

IAEA, Prague, Czech Republic

Vienna, Austria, November 2010

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1. BACKGROUND AND OBJECTIVES

Background

In addition to their investigations into nuclear science, commercial services, and academic education programmes, research reactors (RRs) have historically supported the initiation and fulfilment of national nuclear power programmes. Moreover, RRs have risen to a broad perception as a valuable first step towards a nuclear power programme in order to help establish necessary nuclear infrastructure and train power plant operators. A number of countries have followed this path and, through operation of their respective RRs, now seek to invest in their first nuclear power plants in the near future.

However, in parallel with economic analyses, site studies and other necessary preparations, each RR must institute its own comprehensive training programme for nuclear operators and managers; staff members responsible for nuclear fuel and waste management; and safety and regulatory authority personnel that oversee safe operation practices, strict licensing and maintenance regimes, responsible radiation protection and the handling of waste and other radioactive materials. Just as RRs must serve as a centre for the transfer of knowledge to future nuclear power plant staff, the international RR community can and should lend many valuable lessons from their experiences in supporting national nuclear power programmes to these newcomers, which is in line with the IAEA's mandate for supporting regional and international cooperation regarding the peaceful use of nuclear knowledge and technology. An example for such cooperation is the Research Reactor Group Fellowship Training course, supported by the IAEA and implemented by the Eastern European Research Reactor Initiative (EERRI) that introduces trainees from developing countries to nuclear operations via lectures, simulations and hands-on exercises at various European RR institutes. Similar initiatives are being discussed in Asia and Latin America.

Indeed, Member States interested in building a peaceful nuclear power programme should be able to send their staff to established training centres for dedicated training courses to be replicated in their home countries, ensuring the transmission of best practices and international standards in human capacity and infrastructure building in the area of nuclear power. Additionally, such services will also help remedy the underutilization of the involved RRs, another IAEA goal, as they attempt to facilitate the renaissance of nuclear power.

This consultancy meeting should address all salient questions regarding the establishment and operation of a new education and training centre around existing or new RRs and its regimen by engaging the host party, the initial customers, and the IAEA. Through dialogue and sharing of good practices, experienced and newcomer states will be able to express their capabilities and needs associated with the centre, while the IAEA will gain an understanding of how it can best support such projects.

Objectives

This meeting has focused on the practical methods and issues related to the use of research reactors (RR) in education and training in newcomer states that have a desire to create nuclear power programs. The specific objectives of the meeting were:

- Review the legacy of existing training programmes and evaluate their abilities to support an educational and training centre for newcomer states, including hands-on training at the RR

- Discuss the needs of newcomer states in terms of training future nuclear power plant staff in order to coordinate a relevant and thorough training programme, supported by the RR
- Discuss how international cooperation and IAEA's support can assist in producing and sustaining effective training at the centre and the participating RR institutions
- Draft a model project establishing an education and training centre around the RR that illustrates a training curriculum, funding sources, manpower and attendance requirements, among other operations details
- Discuss means to promote establishment of additional regional educational and training centres around existing or planned RRs in order to cover the needs for future newcomer states

The meeting also provided a forum to exchange ideas and information through scientific presentations and brainstorming discussions, leading to the following overall objectives: 1) enhancement of RR training in Member States by providing practical examples, and 2) providing examples of successful cooperation between different RR centres for the purpose of training and education.

2. WORK DONE AND RESULTS ACHIEVED

The consultancy meeting was attended by 10 participants from Argentina, Belgium, Czech Republic, France, Morocco, Sweden, Turkey, USA, Vietnam, and a Research Reactor Officer from the IAEA. The meeting started off with welcome, opening and introductory remarks by Prof. Miroslav Čech, Dean, Nuclear Sciences & Physical Engineering, Czech Technical University and Mr Lubomir Sklenka (Czech Technical University). Afterwards a welcome address was given by Mr D. Ridikas, the IAEA Scientific Secretary of the meeting, Physics Section, Department of Nuclear Sciences and Applications, followed by self introduction by all meeting participants. Mr A. Çaoui (CNESTEN, Morocco) was nominated as a chair person and Mr S. Reese (Oregon State University, USA) was appointed as a *rapporteur* of the meeting. Mr D. Ridikas, the IAEA Scientific Secretary outlined the specific objectives of the meeting.

In the following sessions, all participants presented their views on the subject of this meeting. The presentations were followed by lively discussions amongst the participants. Further, intermediate summaries and compilations of findings and comments contributed to involving participants into the aims of the meeting and the strengthening of the exchange of knowledge and experience.

This meeting was acknowledged as an important international event connected to the celebration of the 20th anniversary of the operation of the training reactor VR-1 at the Czech Technical University – one of the key members of the Eastern European RR Initiative (EERRI). Through the next three days, many examples born from the success of this collaborative effort were described. Part of the discussion that ensued revolved around how to leverage the success of EERRI directly with training and education towards developing nuclear power programs.

Furthermore, the VR-1 reactor at the Czech Technical University is specifically utilized as a dedicated educational facility that is also used for training. The participants of this meeting had the unique opportunity to tour this facility and learn in detail how it is utilized. The participants also toured the zero power LR-0 facility and the 10 MW multipurpose research reactor LVR-15 in Řež. These two facilities provided excellent examples of the differences typically seen in research reactors because, in contrast to the VR-1 reactor, the other two reactors are utilized in a specific research capacity, including commercial applications, and are less involved with training and education.

The location of this meeting was a superb choice for not only the convenient ability to tour applicable facilities but also the excellent hospitality and accommodations provided by the host, Czech Technical University.

The Annexes of this report include:
I. book of individual abstracts,
II. role of RRs in NPP programmes by country,
III. contribution of RR to the requirements for NPP programme development,
IV. list of typical E&T experiments performed at RRs,
V. meeting agenda, and
VI. list of participants.

Copies of the presentations, papers and administrative information were distributed during the meeting to all participants and may be obtained from the Scientific Secretary on request. The full meeting report as a working document is also available on request from the Scientific Secretary.

Presentations and Discussion

Individual presentations were given by the experts over the course of two days. Abstracts of each presentation can be found in Annex I. A summary of each presentation is included here as well as the highlights of the discussions that ensued.

The first presentation was by **Mr Ridikas (IAEA)**, as part of an introduction for the meeting. He provided a summary of the current issues facing research reactors worldwide, statistics describing research reactor utilization, and issues facing newcomer states as they pursue a national NPP programme. Topics covered include:

- The rationale and objectives of this meeting
- IAEA database of research reactors
- New research reactor development and construction
- IAEA programmatic structure supporting research reactors
- Regional cooperative efforts
- Developing IAEA coordinated research and Technical Cooperation projects
- Information on three main IAEA web links
- Announcement of International Conference on Research Reactors in Rabat, Morocco 14-18 November 2011

The Chairperson solicited ideas on formalizing the goals of the meeting and discussion ensued. In general, the desire was for countries interested in developing nuclear infrastructure to provide perceive needs while those from countries with developed nuclear infrastructure describe what their experiences have been.

The IAEA has a document which describes millstones for NPP development and is creating an equivalent document which identifies milestones for developing research reactors. However, the role of research reactors in supporting nuclear power is not explicitly defined in either document. An important consideration of this meeting would be to explore this question and provide recommendations.

The consensus was that there should be three questions to ask ourselves after each presentation. These three questions were:

1. How can research reactors assist in development of NPP infrastructure?

2. What could be the criteria to define the educational training center? How are these modified by regional or national considerations?

3. What would an education and training programme look like?

Mr Blaumann (Argentina) gave a presentation on the Argentina experience with respect to research reactors training and education. The primary subjects presented include:

- Overview of research reactors in Argentina
- Overview of available curricula
- Overview of research reactors integration into the curricula
- Examination of the potential for remote (distance) education in the nuclear engineering and sciences related to research reactor operation and laboratory experiences

During the discussion which followed, it was stated that in Argentina nuclear science curricula is established by a national committee (CNEA). The programme appears to be very well developed and does, to a limited extent, involve training for NPP personnel. There were also multiple comments on the significant involvement of science and engineering students within the Argentinean curricula in true reactor operations, not just physics measurements.

Mr Vittiglio (Belgium) gave a presentation on the experiences of training and research reactors in Belgium. The primary topics covered include:

- SCK·CEN organizational structure and missions
- Overview of training courses offered at SCK·CEN facilities including radiation protection, nuclear emergency management, waste management and disposal, decommissioning, the current state of nuclear technology in Belgium
- Overview of the BR1 reactor and training courses that utilize the BR1 facility
- Overview of the VENUS reactor and direct applications to NPPs such as code validation studies and the ongoing GUINEVERE project related to the R&D of ADS

During the discussion which followed, it was pointed out that their education and training experiences are as much European as Belgium, routinely involving students from all over Europe. It was also noted that one very nice aspect of their training programs are that they have multiple training modules at various levels. A discussion ensued regarding funding for training programs. The speaker confirmed that there is an expectation that nuclear industry pays full cost but that most education/university programs generally are already part of the university tuition. However, compensation for foreign student training is arranged on a case by case basis.

Mr Sklenka (Czech Republic) gave two presentations. The first examined nuclear education and training from an IAEA perspective and a second looked at educational and training from a Czech (national) perspective. These presentations concentrated on the numerous collaborations and coordination efforts among regional facilities. The primary topics include:

- The Wigner Course (Coalition) of four universities in Hungary, Austria, Czech Republic and Slovakia was described and discussed
- Eastern European Research Reactor Initiative (EERRI) (Coalition) was described and discussed. EERRI provides a wide variety of capabilities because of the diverse nature of the involved research reactor facilities
- Education and training is easier to coordinate between facilities than research, other experiments or commercial applications due to the sophisticated nature of experiments and the expense of larger reactors, including market competition in certain cases
- The nuclear infrastructure and fuel cycle within the Czech Republic from uranium mining to spent fuel storage were described
- The shortage of knowledge in anticipation of the nuclear renaissance is recognized and several efforts are underway to increase both training and student quality
- The level of detail for research and experiments for the different levels of academic standing (i.e., BS, MS and PhD) were discussed
- The capabilities and expertise available at the VR-1 facility were described in more detail.

During the discussion period, it was pointed out that there are problems with the course accreditation but that it really wasn’t necessary from the view of the IAEA. One of the reasons why EERRI was successful for IAEA training courses was that taken together these facilities provided a complimentary synergistic capacity (no single reactor facility wouldn’t likely have the ability to allocate the time and resources necessary for the course of 6 weeks, including hands-on-training). A consistent and coherent message is necessary, however, for reactor safety issues and this was achieved by pulling in the IAEA experts. For reactor utilization and training topics, multiple perspectives were considered valuable and necessary. There was consensus that the driving factor to attract quality students is driven by job/career potential. There was much discussion on the process of why, where, who and how of research reactor development. The conclusion was that the “why” and “where” are usually political decisions, but the “who” and “how” are controllable by the facilities themselves. One final note is that most research reactors which have either failed or are underutilized where associated with poor political choices with respect to “why”, or simply were not able to develop their new strategies related to the time-dependent needs and purpose of the research reactor facility.

Ms Zakova (Sweden) gave a presentation on development of a new training reactor in Sweden. The primary items presented included:

- Training and education needs in the nuclear sciences in Sweden are now recognized by the government. As such, two research reactor projects have started.
- The STURE low power reactor (<30kW) project was described (in support of E&T).

- The ELECTRA dedicated reactor project was described (in support of Generation IV).
- The nuclear research and development capabilities in Sweden were described with special emphasis on lead-bismuth expertise and fast neutron technologies.

During the discussion period, there was interest in the long-term operational costs of the two reactor projects. The target audience for these reactors will likely be that STURE will concentrate on the domestic need for training and education while the ELECTRA project will solicit interest international due to the uniqueness of the lead-bismuth coolant and fast neutron environment.

Mr Foulon (France) gave a presentation on training programs with research reactors in France. The primary items presented include:

- The nature of academic and continuing education were described
- The primary research reactor used for research and education is the ISIS reactor in Saclay, but there are three other small power reactors that are occasionally used for training. The ISIS reactor was described in detail
- The relationship and role of tools used in nuclear E&T (i.e. software, simulators, and research reactors) were described.
- The scheduling, coordination, and operational issues at the ISIS reactor were discussed.

During the discussion period, the relationship between the ISIS facility and OSIRIS multipurpose research reactor was discussed. Because ISIS is a low power mock-up of OSIRIS and that they are co-located, they share some personnel such as engineers and radiation protection personnel. The most requested type of training courses are usually the type of course that can be completed in one day. This typically involved exercises like approach to criticality, rod calibrations, influence of delayed neutrons, and temperature and Doppler feedback. In most cases, students would not physically operate the reactor, but rather obtain and discuss output of the associated nuclear instrumentation. However, in the qualification process of operators of the French research reactor, the trainees operate the reactor under the supervision of the ISIS staff. As in the United States, research reactors in France are not typically used for training of NPP operators.

Mr Çaoui (Morocco) gave a presentation on the experience of creating a nuclear research and technology center in Morocco. Morocco is a country that has expressed a desire to the IAEA to explore creation of the NPP program. The primary items presented include:

- The driving factor for Morocco is the need for increased electrical capacity.
- To support the development of nuclear power, a decision was made in the 1980's to create a nuclear science center, called the National Centre for Nuclear Energy, Science and Technology (CNESTEN).
- A wide and in-depth program has been developed for CNESTEN, ranging from hydrology to isotope production.
- CNESTEN has established the regulatory environment through the licensing. It is interesting to note that the experience of research reactor licensing and creation of other related infrastructure will help them with the development of NPP programme.

During the discussion session that followed, questions were asked regarding isotope production. There is a large radiopharmaceutical group which will be producing primarily radio-iodines and Mo-99. There was some discussion on cooperation between research reactor states. Although there is not much in the way of cooperation between reactor facilities in North Africa, there are good relations with most of sub-Saharan African countries. It was emphasized that the 19 IAEA criteria to consider in the development of NPP programme were already explored with the creation of CNESTEN. It was pointed out that CNESTEN, while receiving some outside assistance, was the group responsible for writing and submitting their safety analysis report.

Mr Tinh (Vietnam) presented the experience of Vietnam with the program for development of a NPP programme and associated human resources development issues. Vietnam has also expressed interest to the IAEA in exploring the possibility of pursuing a NPP programme. The primary items presented included:

- Vietnam is committed to developing a NPP programme by 2020.
- Because of population growth and the fully developed hydro power program, energy demand has been exceeded and will continue to exceed the installed capacity.
- Developing programs in human resource development to meet the technical needs of a NPP programme is currently the biggest concern.
- There is a TRIGA-type research reactor in Dalat that is the basis for current nuclear science training and education. Plans are in place for strengthening nuclear science curriculum at 6 national universities.
- There is recognition that a new low power research reactor for E&T purposes needs to be built as the Dalat research reactor facility will be closed in 2015.

During the discussion session, it was stated that a vendor for both the NPP and research reactor has not been selected. It was pointed out that the NPP programme is very ambitious in terms of number of plants, total capacity, and required human resources. It was emphasized that a domestic academic program should start immediately. The majority of participants agree that in the short term the best strategy is to obtain advanced degrees at foreign academic institutions, and preferably in the form of "train-the-trainer" strategy, but in the long term a domestic academic infrastructure was needed. It is clear that Vietnam had embarked on a research reactor programme prior to the development of NPP. There was also discussion regarding the need for developing a high power research reactor by 2015. If there is a desire to pursue isotope production or embark upon a material science program, then building a high power reactor is justified. However, for direct support of the NPP programme in the short term, the country might be better served concentrating on a new zero-power or low power research reactor, or exploring possibilities to adopt the existing research reactor exclusively for E&T purposes in support of the national NPP programme.

Ms Tuğrul (Turkey) presented information on Turkey's programme on NPP development. Turkey has express interest to the IAEA on exploring a potential NPP industry. The primary topics discussed were:

- A brief history of the nuclear science and engineering organizations, including the regulatory authority and the development of the research reactor infrastructure (i.e., TR-1, TR-2, and ITU TRIGA) within Turkey were presented.

- A significant amount of work has been done in recent years accrediting various nuclear facilities, services and procedures.
- A brief history and the current state of nuclear academic programmes were presented.
- A brief history of nuclear power development in Turkey was presented.

During the discussion period, it was stated that when it comes to operating the proposed NPP, it could be completely foreign owned and operated under a build-operate-transfer (BOT) model. The spent nuclear fuel would be transferred to the foreign entity but Turkey would likely control the medium and low radioactive waste domestically. The "operating language" of the NPP will likely be English. Because of the BOT agreement, there may be limited need for long term academic programs in nuclear engineering or radiation protection, although Turkey would still need to act as a licensing and regulating organization of their future NPP. The final decision on the creation of these new academic programs is still uncertain. It was noted that Turkey chose the option of building a research reactor first before their NPP programme was developed and that this has served them well. The research reactors have provided a benefit to understanding and developing needed nuclear infrastructure, establishing safety and regulatory authorities, etc.

Mr Reese (United States of America) gave a presentation on both training and education at a university and general comments on research reactors in the US. The primary topics included:

- The Radiation Center as a centralized facility for use of nuclear technology was described.
- Involvement of faculty and students with the research reactor was described.
- It was emphasized that research reactors in the US are typically located on universities which significantly influences how they are operated.
- Academic programs and research reactors are not centrally organized by the federal government.
- Research reactors in the US are minimally involved with requalification programs for operators at NPPs.

During the discussion which followed, it was stated that students graduating from the academic program typically go to a further graduate education, government laboratories and vendors but few go on to commercial NPPs. It was noted that a business model for operating the facility was used which contrasts with centrally created or organized facilities.

3. SUMMARY AND CONCLUSIONS

Focusing on the key objectives of the meeting, a number of key questions were addressed. These questions are related to the role of research reactors in training and research for many applications in nuclear sciences but also more specifically in their role in training human resources and other infrastructure development in countries developing NPP programmes.

1. *Review the legacy of existing training programmes and evaluate their abilities to support an educational and training centre for newcomer states, including hands-on training at the RR.*

- Research reactors provide a valuable tool for any nuclear educational and training centre for not only newcomer states but also for countries with established NPP programmes. It should be noted that initially those countries with established NPP programmes started with research reactors.
- Research reactors are a highly valuable and convenient tool for demonstrating reactor core neutronics principles and instrumentation behaviour. Reactor simulators and research reactors, thanks to their real hands-on-training capabilities, provide very complimentary E&T capabilities. As part of the complete training of engineers, scientists and operators, practical time operating and experimentation on a research reactor remains invaluable and of great importance.
- There is a clear advantage to siting a research reactor at a university because of access and convenience in support of nuclear educational programs. However, it is not a necessity as there are examples of successful research reactor programmes not located at a university but rather at dedicated training, research and technology centres.
- Examples of educational and training programmes that utilize research reactors are well established and do exist. Therefore the sharing of knowledge and good practices is encouraged. Train-the-trainer programmes should be prioritized and supported at the 1st stage in order to develop national nuclear infrastructure at the 2nd stage.

2. *Discuss the needs of newcomer states in terms of training future nuclear power plant staff in order to coordinate a relevant and thorough training programme, supported by the RR.*
    - Countries developing a NPP infrastructure should ultimately rely on a national capability for training and education. While some components needed to perform the necessary training and education may take time to develop, creation of a domestic and sustainable nuclear E&T programme capability should be the goal. A dedicated research reactor would provide an advantage to such an E&T programme.
    - Research reactors are an important component of any nuclear training programme and infrastructure development in support of a future NPP projects. All three newcomer member states present at this meeting have constructed research reactors as a first step, underscoring its importance. However, formal training and education programmes still have to be establish and targeted towards personnel at all levels of the needed future nuclear community (i.e., the general public, students, engineers, operators, inspectors, regulators and managers) that will be present/involved with NPP infrastructure.
    - An extremely important role of a research reactor as the 1st step for the newcomer country in achieving 19 IAEA requirements, describing the readiness of the country regarding the NPP programme, was clearly confirmed: more than half of these requirements could be covered at least in part through the RR project.
    - While difficult due to the unique nature of each targeted audience/trainees to be educated, research reactors around the world might benefit from a

recommended curriculum (i.e., guidelines) for research reactor-based experiments that has flexibility built in such that more advanced participants can quickly get experience and hands-on-training in more difficult concepts or experiments.

- Newly developed training programmes in the newcomer states should consider developing an experienced team from a research reactor who has sufficient knowledge providing targeted E&T programmes for specific groups of customers (i.e., the general public, students, engineers, operators, inspectors, regulators and managers). It is recommended that the IAEA support such efforts.

3. *Discuss how international cooperation and IAEA's support can assist in producing and sustaining effective training at the centre and the participating RR institutions.*
   - The sharing of training module information between the newcomer states and countries with existing NPP programmes is of vital importance to the nuclear training centers in those newcomer states.
   - The IAEA should consider publishing a guidelines document that provides detailed information on reactor experiments as part of the E&T curriculum. The experiments should not be limited to reactor core physics but should include exercises in fundamental nuclear principles. Additionally, the document should provide a list of concepts that different groups of trainees should be expected to understand.
   - Newcomer states developing research and training programmes in support of their NPP programmes should also consider utilization of research reactors as part of the operator requalification programmes for NPPs.

4. *Draft a model project establishing an education and training centre around the RR that illustrates a training curriculum, funding sources, manpower and attendance requirements, among other operations details.*

- The newcomer states with existing research reactors should be encouraged to develop E&T programmes in support of their NPP programme and centered around the use of their research reactor. In this case, existing expertise and experience with activities associated with the research reactor or facilities utilizing other nuclear techniques should form the nucleus of this new NPP programme.
- For the newcomer states without a research reactor, it is advisable, as a first step for developing and implementing a necessary nuclear infrastructure, to create a national research reactor facility or obtain agreements with regionally located research reactor facilities. The knowledge and experience gained through the implementation of the research reactor facility is a valuable and manageable first step for creating the larger scale NPP infrastructure. Moreover, the dedicated RR facility will provide a continuous support and assistance in the ongoing NPP programme.

5. *Discuss means to promote establishment of additional regional educational and training centres around existing or planned RRs in order to cover the needs for future newcomer states.*

- When a regional approach for training and education is appropriate, it is recommended that the IAEA help in *initially* coordinating the structural organization around the existing or planned research reactor. However, it would be the responsibility of each regional member to financially support and sustain the training center. These new regional training and education centers would be at great advantage to include collaboration and support from existing and well established organizations.
- When a regional approach for training and education is appropriate where there are multiple existing facilities, it is recommended that the IAEA assist in *initially* coordinating the structural organization between these facilities. A successful regional approach would provide complimentary expertise and facilities, not available otherwise. However, it would be the responsibility of each regional member to financially support and sustain the coordinated effort. These new regional training and education centers would be at great advantage to include collaboration and support from existing and well established organizations.

4. RECOMMENDATIONS

The meeting adopted the following concrete recommendations, both to the IAEA and Member States, satisfying the stated objectives of examining the education and training capabilities of research reactors, promoting cooperation between different research reactor centres and end-users, and determining the potential for the application of research reactor training and education for national NPP programmes.

I. **When a newcomer state expresses a need for developing the 1st NPP programme, the development of a research reactor as the 1st step is a recommendable practice.** Indeed, the Member States (newcomer countries presently and NPP countries in the past) present in this meeting, all followed this path and confirmed the great benefit of having a research reactor both in terms of infrastructure and human resource development, operating experience, regulation and licensing, establishing of nuclear safety and security culture, public acceptance, etc.

II. **The newcomer states with an existing research reactor are encouraged to develop dedicated E&T programmes in support of their NPP programme and centered around their existing research reactor.** In this case, existing expertise and experience with activities associated with the research reactor or facilities utilizing related nuclear techniques should form the nucleus of this new NPP programme.

III. Examples of educational and training programmes that utilize research reactors are well established and do exist. Therefore the sharing of knowledge and good practices should be encouraged. **In this context, the IAEA should assist the newcomer states in train-the-trainer programmes, based on well established research reactor facilities, as the 1st stage to develop national nuclear infrastructure and corresponding human resources.**

IV. **The IAEA should consider publishing a guidelines document that provides detailed information on research reactor experiments as part of the nuclear E&T curriculum.** The experiments should not be limited to reactor core physics but should include exercises in fundamental nuclear principles (e.g. neutron beam experiments, nuclear data measurements, etc.)

V. The IAEA should consider coordinating a national workshop(s) in a newcomer state(s) that would provide an opportunity to investigate the potential for nuclear education and training programme built upon on a national or regional research reactor. This would allow all facility stakeholders and counterparts (e.g. government, utilities, industries, vendors, universities, research and technology centers, regulatory authorities, etc.) to express their views, share their opinions and consolidate their decision regarding the role of a research reactor in national NPP programme, including potential for a regional cooperation.

ANNEX I. INDIVIDUAL EXPERT CONTRIBUTIONS

1 Mr Herman Roberto BLAUMANN, Argentina

Teaching and training in the Argentinean research reactors. The RA-6 reactor experience supporting nuclear education in the Balseiro Institute

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An introduction was provided about the operating and planned nuclear relevant installations including NPP and new RR that are or might be related to teaching and training in the Argentinean research reactors.

The relevant characteristics of the Argentinean RR were outlined, together with their main applications and detailed activities related to teaching and training, remarking NPP operation teams training and a great variety of courses that help in promoting nuclear culture, as well of the training for foreign countries teams and public education.

Teaching and training institutes from the CNEA, implemented through agreements with national universities for the development of human resources in vacancy areas for technology development project in the nuclear field were presented.

The RA-6 reactor experience supporting teaching and training in the Balseiro Institute was detailed, including undergraduate and graduate courses for nuclear engineering and other nuclear related careers.

2 Mr Guido VITTIGLIO, Belgium

Education and Training Activities at SCK*CEN

SCK•CEN, Boeretang 200, BE-2400 Mol, Belgium

The primary topics covered in this presentation included:

- SCK*CEN organizational structure and missions
- Overview of training courses offered at SCK*CEN facilities including radiation protection, nuclear emergency management, waste management and disposal, decommissioning, the current state of nuclear technology in Belgium
- Overview of the BR1 reactor and training courses that utilize the BR1 facility
- Overview of the VENUS reactor and direct applications to NPPs such as code validation studies and the ongoing GUINEVERE project related to the R&D of ADS

In brief, the nuclear education and training experience in Belgium is very much "European", routinely involving students from all over Europe. The training programs have multiple training modules at various levels. There is an expectation that nuclear industry pays full cost for the training, while most education/university programs generally are already part of the university tuition. Finally, compensation for foreign student training is arranged on a case by case basis.

3 Mr Lubomír SKLENKA, Czech Republic

Role of research reactors in nuclear education and training from Czech perspective

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- Lack of experts and high educated and skilled professionals in nuclear engineering in the world caused by fast aging of the NPPs and research reactors staff and expected "nuclear renaissance" brings new needs to the universities and research reactors. During the last few years some new trends in nuclear education became visible.
- Customers expect high quality nuclear education in wide range of knowledge and the complex services, which forces universities and research reactors to bring new challenges in the domain of education and training.
- State-of-the-art experimental equipment and methodologies specifically developed for the education, networking and close co-operation between universities and research reactors at national and international levels, and sharing the experimental facilities are the trends which can be noticed today all over the world.
- Research reactors are suitable for education of students at all academic levels (Bc, MSc and PhD) not only in nuclear engineering, but also in various non-nuclear engineering studies (power engineering, electrical engineering, natural sciences, medical sciences, physical sciences, etc.).
- An effective way how to provide the education and training at the research reactor is adaptation of the educational methodology to the initial students' background level only way for an effective education. Special effort and special educational instrumentation is needed for education of Bc and MSc students.

Research reactor coalition and nuclear education & training

Czech Technical University in Prague, Czech Republic

- Research reactors follow the trend of networking and closer co-operation between research reactors which was initiated in late nineties between universities in Europe involved in nuclear education.
- Research reactor coalitions were one of the key topics elaborated at the IAEA International Conference on Research Reactors, held in Sydney in 2007. As a result, the Eastern European Research Reactor Initiative (EERRI) was as the first reactor coalition established in 2008. Now four reactor coalitions are established and another three are in progress or planned.
- EERRI Initiative was established for coordination in utilization of the reactors, sharing the experimental facilities, providing complex services to customers and to get synergy benefit for partners. EERRI is working in four fields of interest: Beam applications and neutron scattering, Isotope production, Fuel and material testing, Nuclear education and training.
- During three years of EERRI reactor coalition a lot of experiences have been accumulated. Cooperation and joint activities in nuclear education and training appeared to be easier than in other three fields. Good examples are two EERRI Group Fellowship Training Program on Research Reactors delivered for IAEA in 2009 and 2010. The big issue with highest priority remains how to keep reactor coalition sustainable.

4 Ms Jitka ZAKOVA, Sweden

Program for Development of Domestic Research Reactors for Training and Education in Sweden

Physics Department
Kungliga Tekniska Högskolan (KTH)
AlbaNova University Centre
Stockholm, Sweden

KTH presented two projects of RR; the Swedish Training and Education Reactor (STURE) and the European Lead Cooled Training Reactor (ELECTRA).

A hands-on experience is an invaluable part of future nuclear specialists' education in Sweden. The current model of the reactor training pursued by KTH is based on collaboration with foreign countries. With increasing interest in nuclear education, sending students abroad for the reactor exercises is getting both expensive and logistically complex. For this reason, KTH decided to design new reactor for training purposes: STURE.

KTH presented a basic technical description of STURE as well as a cost estimate (15 M€) outlined by the potential vendor, INVAP. The 10 kW reactor fuelled with UOX fuel, cooled by naturally circulating water would serve mainly educational purposes.

The innovative concept of ELECTRA is a connection of existing Swedish research on LBE, materials, nitride fuels and a focus on future nuclear systems. The in-house design of the 0.5 MW reactor, fueled by (Pu,Zr)N and cooled by natural circulating LBE is being developed further within the 7th framework program project LEADER. ELECTRA is expected to develop expertise in the field of operational procedures for liquid metal, provide some (limited) materials testing for development of MYRRHA & ALFRED and serve educational purpose as a unique facility in the region. KTH invites interested parties to assist in designing a set of laboratory exercises for ELECTRA. Moreover, assistance from the IAEA in coordination would help to ensure good utilization of the facility.

The suggested sitting of both the reactors is at Oskarshamn located on the same site of an existing NPP. This location simplifies the licensing process and decreases the operational costs such as expenses related to site examination, waste management, safety and security issues, etc. The potential source of funding is Oskarshamn municipality and the Swedish government.

5 Mr Francois FOULON, France

Training programme on research reactors at the French Atomic Energy Commission (CEA)

Institut National des Sciences et Techniques Nucléaires (INSTN)
Commissariat à l'énergie atomique B.P. 52, 91191 Gif sur Yvette CEDEX, France

As a part of CEA, the National Institute for Nuclear Science and Technology (INSTN) is a higher education institution under the joint supervision of the Ministries in charge of Education and Industry. It was been created in 1956, when France decided to launch a nuclear programme, in order to provide to engineers and researchers a high level of scientific and technological qualification in all disciplines related to nuclear energy applications. From the very early beginning research reactors were used in order to give a comprehensive understanding of reactor core principles and operation. In particular, from the 60's till now, research reactors were extensively used for hands on training in the qualification process of all the operators of the French research reactors.

Today, INSTN is involved both in academic degree programmes and continuing education courses for professionals, at French and international levels. As an example, international courses with duration of 1 to 11 weeks are organised at the institute, some of these courses being organised in the frame of the European Nuclear Education Network (ENEN). They cover all the domains related to nuclear reactors that includes reactor principles and operation, neutronics, thermo-hydraulics, fuel cycle, safety, criticity and reactor dismantling. Whenever it is necessary to complete and illustrate the theoretical courses, an extensive range of training tools is used, including software applications, simulators and research reactors.

Since 2007, ISIS reactor at CEA Saclay became the main reactor used by CEA for training. In 2004 to 2006, this reactor was especially refurbished and adapted for training purposes. Other research reactors, i.e. Minerve, Eole and Azur (operated by AREVA), at CEA Cadarache are also used for training courses.

An extensive range of experiments is carried out on ISIS reactor to cover the different aspects of reactor operation (fuel loading, reactor start up, reactivity effects, temperature effects, radioprotection, tests and qualification of instrumentation, etc.). For all experiments emphasis is given to the impact of each operation and effect on the safety of the reactor operation, both in normal and incidental situations.

Nine different types of training courses can be carried out, each course having the duration of 3 hours. Depending on the educational objective, sets of 1 to 6 training courses are proposed. In 2011 it is planned to use ISIS reactor 75 days for training courses. For academic purposes most of these courses are planned from October till January. Thus continuing education is mainly scheduled from February to June.

With the development of training activities on ISIS reactor in the frame of academic and continuing education, the number of training courses on ISIS could be increased up to about 180 days/year. Thus, CEA and INSTN are ready to participate and assist in the development of an education and training center that can include hands-on training at research reactors.

6 Mr Abdelmajid ÇAOUI, Morocco

Nuclear Research Centre (NRC) of Maamora: A Technical Support Organization for Nuclear Power Option in Morocco

Centre national de l'énergie, des sciences et des techniques nucléaires (CNESTEN)
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Since the eighties Morocco has been considering nuclear power as an alternative option for the future as the country imports almost all the energy sources. It is in this framework that Morocco first set up a Nuclear Research Center (NRC) of Maamora at the turn of this century. This center is equipped with 2 MW TRIGA-type research reactor which became critical in 2007 and obtained its operational license in 2009.

The public authorities consider the NRC as the main infrastructure to build up a national capacity toward a nuclear power (NP) programme. Regarding the milestones approach adopted by the IAEA to develop the NP infrastructure, the process of setting up the NRC in Morocco has enabled the country to acquire competencies in fields related to:

- Nuclear Safety: adoption of IAEA standards for design of the NRC project, setting up all the Safety analysis reports and establishment of safety organization for the operation of research reactor;
- Legislative framework: adherence to the international instruments concerning the NPT, safeguards, safety and security regime;
- Regulatory framework: establishment of the regulatory body and management of licensing process review and assessment of the NRC with the support of national safety committee;
- Radiation protection: establishment of specific infrastructure to control the operational activities of NRC which became recognized by the IAEA as regional center in Africa;
- Development of a national nuclear Security regime: the physical protection of the NRC is conducted with the support of the institutions concerns;
- Radioactive waste infrastructure for low and intermediate level are the main infrastructure for the country to prepare a national policy
- Environmental protection studies and survey: experience acquired for the NRC site could be developed for NPP;
- Emergency planning: the concept adopted for the NRC is actually developed at a national level;
- Nuclear techniques capacities: as the NRC promote the various nuclear applications, the center host many trainings events for the students and professional staff
- Human resources' development: in general the center considers the RR as the new tool for the development of human resources in nuclear sciences and reactor physics. In this view a great importance is given to the collaboration with universities and other institutions;

In conclusion the NRC in Morocco supports strongly the suggestion of the establishment of the new education and training centre with a RR as an important component. The assistance from the IAEA directly or through the existing regional RR coalition is of great importance to implement such a centre.

7 Mr Nguyen Trung TINH, Vietnam

Nuclear program and issue of training human resources in Vietnam

Electric Power University
235 Hoang Quoc Viet Str.
Tu Liem, Hani, Vietnam

With the present population of 86 millions and the economic growth rate of ~8 % per year, the energy security and the enhancement of scientific and technological potentials of the country are vitally important for sustainable economic growth, social security and living standards improving. Therefore, the Government of Vietnam has paid much attention to the policies for sustainable energy development, including nuclear power development. That is why, on 3rd January 2006, the Prime Minister approved the Long-term Strategy for Peaceful Utilization of Atomic Energy up to 2020, emphasizing the important goals for building the first nuclear power plant (NPP) in Vietnam.

Historical development

For development nuclear power program in Vietnam, from 2002, the Prime Minister of Vietnam decided to establish the Governmental steering Committee for development of nuclear power in Vietnam. After that, on 3rd Jan. 2006, the Prime Minister approved the long-term strategy for peaceful utilization of atomic energy in Vietnam up to 2020, in which the nuclear power program has been determined. The object of the nuclear power program consist construction and put into operation of the first NPP in Vietnam in 2020; step by step to increase ratio of electricity from NPPs up to considerable percentage in the period of 2030-2040; preparation of all nuclear infrastructures required and development of national capabilities for self-reliance of nuclear power technology in the future.

In 2007, the Pre-FS for the 1st NPP in Vietnam and the Master Plan of Power Development No VI up to 2025 have been approved by the Government, showing the planned nuclear power will reach to 8,000 MW in 2025. On 3rd June 2008, The Atomic Energy Law was passed by the National Assembly. On November 2009, the NinhThuan NPP Project with two NPPs at two sites NinhThuan 1 and NinhThuan 2 of total capacity of 4000 MWe was passed by the National Assembly. For preparing human resources for NP Program, on 18th August 2010, the governmental project on training human resource in atomic power field approved by the Prime Minister. In order to make the long term developed nuclear power program to develop the economic of country, on 17th June 2010, The Prime Minister signed decision of the Master Plan of Nuclear Power Development up to 2030 with the total capacity of 15.000 MWe (15 % total capacity of electricity).

Human resource is very important with all program, especially with Nuclear Power Program, because we cannot develop the NP Program stability and sustainability without the good man power. Experiences of countries having NPPs show that human resource for 1 NPP with 2 units-1000 MWe/unit needs 800-1200 staffs. Only up to 2022, Vietnam will have 2 NPPs with 4 units, and therefore the need for ~ 2000 staffs, while up to 2030 Vietnam will needs 7000 staffs. Therefore, on 18th August 2010, the governmental project on training human resource in atomic power field with the funding of about 160 million USD was approved by the Prime Minister. The finance will be used for: sending teachers to abroad for studying and preparing lectures; sending students to abroad for learning; inviting professors and experts from foreign countries to give lectures; set up the sandwich training program for undergraduate and graduate; set up laboratories and necessary equipments.

Training on Research Reactor in Vietnam

Dalat NRR is a Pool-type, water-cooled and water moderated TRIGA MARK-II research reactor with thermal power of 250 kW and upgraded to 500 kW in March 1984. The reactor has been safely operating since 1984 and exploited for: production of radioisotopes and radiopharmaceuticals (main products: I-131, P-32, Tc-99m generator); research on neutron physics, reactor physics and dynamics, nuclear data, neutron activation analysis; neutron radiography, silicon doping, and training and education.

As the unique reactor in Vietnam so far, the Dalat RR plays an important role for training undergraduate and graduate in Vietnam in the subjects of: Radiation protection and Nuclear safety; Applications of nuclear techniques in industries and environmental study and others.

After a long time training in the field of nuclear physics, only now we are preparing for training in the field of nuclear engineering. It was recognized that the research reactor takes an important role in training human resources, infrastructure development, nuclear research and various applications.

Issue of human resources in Vietnam

Human resources development (HRD) for NPP is crucial issue within the national NP program. Equally, development of necessary nuclear infrastructure is also required for self-reliance of nuclear power technology in the future. So, in the future, we need set-up the National Steering Committee for Nuclear HRD; implement of the national nuclear HRD Program including HR for the first NPP project, HR for development of required national nuclear infrastructures, and HR for utilizations of radiation and radioisotopes; upgrading nuclear faculties in 5 universities in the country including curriculum, teaching materials, lecturers and facilities, including a construction of a new zero power Reactor; establishment of the nuclear training center at the VAEI, VARANS and EVN as an advanced center for training nuclear technology engineering and safety, related master and doctoral courses; establishment of a multipurpose research reactor.

Conclusion

We invite the regional and international cooperation on nuclear power development in Vietnam on the following topics: Training of Human resources; constructing; operating; radiation control; licensing; waste management; decommissioning.

8 Ms A. Beril TUĞRUL, Turkey

Training and Research Studies in Turkey at The Stage of Nuclear Power Plant Establishment

Nuclear Researches Division – Energy Institute
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İstanbul – TURKEY

In Turkey, peaceful usage of the nuclear energy has been put into the agenda already in early 50s. In that context, related regulations, rules and guides have been developed with the international meetings and related assignments. Turkey, has signed the Nuclear Non-Proliferation Treaty (NPT) by the acceptance of the Turkish National Parliament in April 1980. Many regulations and arrangements related with nuclear energy activities have been improved by the Turkish Atomic Energy Authority (TAEA) and TR-2 Research Reactor has placed in TAEA_Çekmece Nuclear Research and Training Center.

Nuclear education has mainly attended in three Universities in Turkey, namely Istanbul Technical University, Hacettepe University and Ege University. The one and the only operational University research reactor in Turkey is in ITU Energy Institute. This research reactor is TRIGA Mark-II type with its power of 250 KW.

Regarding to the contract related to the nuclear power plant that has been signed between Turkey and Russia, two countries are obligated for NPP with the model of Build-Operate-Transfer (BOT). In that case, Turkey will be involved in the licensing, regulation and inspection process. Therefore, there will be the need of skilled personnel in that context covering all necessary areas of expertise.

Since Turkey has had the idea of a nuclear power plants for long years, some required expertise staff was developed. However, an important number of these people either work in different fields or emigrated. Therefore, during the building of the nuclear power plant and through the licensing/operation period, these and new people should become available. Additionally, it will of great importance to request the assistance and support of the experts from the IAEA in this context as it was done in the past and in different areas.

9 Mr Steve REESE, United States of America

Training and Education at the Oregon State University TRIGA Reactor

Radiation Center
Oregon State University
Corvallis, Oregon, 97330 USA

The Radiation Center on the campus of Oregon State University is a facility specifically designed for the utilization of radioactive materials and nuclear technology. It has many facilities utilized for teaching and research including laboratories, high bay test laboratories, gamma irradiators and a reactor. The operating philosophy of the Radiation Center is described. Additionally, the number of student and faculty as well as the types of research performed is given as examples of a vibrant and well-rounded educational environment.

The Oregon State TRIGA Reactor (OSTR) is a 1 MW TRIGA Mk II reactor that was originally built in 1967. The OSTR has recently gone through two significant changes: the process of obtaining a 20-year license extension with the regulatory authority and converting the reactor from high enriched uranium to low enriched uranium fuel. The facility management used these changes as an opportunity to involve both faculty and students.

In the US, most research reactors are located on universities and national laboratories. The role that US research reactors located at universities play in education and training is discussed. Examples of successful and unsuccessful facilities are described. While research reactors in the US are typically not involved with commercial power training, they are excellent tools for and are extensively used in education and research. As such, they form the basis for practical laboratory experience supporting manpower development in the US.

ANNEX II. ROLE OF RESEARCH REACTORS IN NPP PROGRAMMES BY COUNTRY

Role and importance of a small power RR (e.g. <3MW) as the 1st step in NPP programme for each participating country are summarized in the table below. The inputs are divided into those with existing NPP programmes and those that are interested in developing the NPP programmes in the future.

Country	National NPP programme	NPP Operators, Other Staff	Safety Authority Staff	RR Operators, Staff	University Students	Foreign Relations	Other Use (e.g. NAA)	Public Relations
Argentina	M	S	P	S	S	S	S	S
Belgium	M	P/N	M	S	S	M/S	S	S
Czech Rep.	M	M	S/M	S	S	S	P	S
France	P	M	S	S	S	S	S	P
Sweden	M	M	P	S	S	S/M	S	S
USA	P	P/N	P	S	S	S	S	S
Morocco	S	P	S	S	S	S	S	S
Turkey	P	P	M/S	S	S	P/M	M	S
Vietnam	M	P	M	S	S	P	M	M

Notations:
S – strong role, M – moderate role, P – potential role, N – no role.
Blue: Existing NPP programme, **Red**: NPP programme under development.

In summary, research reactors are excellent tools in the university or research centre setting, contributing significantly to research, technology and education. However, the role research reactors play for power reactor operations is highly country dependent. It appears that in countries developing NPP programs, research reactors play an important role in creating the initial infrastructure. For countries with existing NPP programs, research reactors historically played an important role creating this infrastructure but now occupy less important place in mature NPP programs in an operational sense. On the other hand, they continue to provide invaluable service for education, research, technology and other services for national nuclear infrastructure.

ANNEX III. CONTRIBUTION OF RESEACH REACTOR TO THE REQUIREMENTS RELEVANT TO NPP PROGRAMME DEVELMENT

Role of RR as the 1st step for the newcomer country in achieving 19 requirements, describing the readiness of the country regarding the NPP programme were discussed. In the table below, the applicability and role of research reactors was evaluated and comments provided.

Requirement	Role	Comment
National Position	S	A clearly established position of the government on the development of a new or/and use of an existing research reactor as the 1st step is of great importance and should facilitate the future development of NPP programs.
Nuclear Safety	S	Research reactors must be operated in a safe and effective manner. Governments must commit to following established international nuclear safety standards, protocols and guidance.
Regulatory Framework	S	As with nuclear safety, governments must implement established international standards for an independent regulatory body.
Radiation Protection	S	Radiation protection of the workers and general public is absolutely required.
Funding & Financing	P	Because the costs associated with construction of a research reactor are significantly smaller and can usually fall within the budget for a government, funding issues can typically be overcome even when presented with difficulties. This is also a political decision.
Human Resource Development	S	Research reactors are vital first steps in creating training and educational programs in support of human resource development.
Safeguards	S	Control and accountability of radioactive and special nuclear material is an essential part of a nuclear operation. This usually involves international commitments and agreements.
Security and Physical Protection	S	Security of radioactive and special nuclear material is an essential part of a nuclear operation.
Emergency Planning	S	Emergency planning is an essential part of a nuclear operation.
Nuclear Fuel Cycle	P	Governments need to be aware of issues related to supply and spent nuclear fuel storage/disposition and create national policy. Research reactors may provide informative practices for NPP environments.
Radioactive Waste	M	Governments need to be aware of issues related to radioactive waste management and create national policy. Research reactors will provide informative practices for NPP environments (at a different scale or quantity).
Environmental Protection	S	Environmental protection for research reactors

		provides valuable experience when analyzing impacts to the environment, although at a significantly smaller scale than NPP.
Legislative Framework	S	As with nuclear safety, governments must follow established international standards for establishing laws related to use of nuclear systems and materials.
Sites & Supporting Facilities	S & P	Siting (S) and support facilities (P) for research reactors provides valuable experience when determining impacts for larger NPP programs, although at a significantly smaller scale than NPP.
Stakeholder involvement	S	Learning about stakeholder concerns is important to understanding issues and public perceptions regarding either research reactors or NPP programs.
Electrical Grid	N	Research reactors play little or no role/relationship with the electrical grid.
Management	P	Because the scale, goals, and complexity are so much larger for a NPP program, research reactors are less likely to provide relevant information.
Industrial Involvement	P	Research reactors are involved in only a limited way with respect to industrial involvement.
Procurement	P	Because the scale, goals, and complexity are so much larger for a NPP program, research reactors are less likely to provide relevant procurement processes. Some exceptions may be purchase and receipt of fuel, nuclear instrumentation, etc.

Notation: S – strong role, M – moderate role, P – potential role, N – no role.

It is clear that in more than 50% of the above criteria research reactors could play a strong role in the development of a NPP infrastructure. While a rank of strong indicates significant contribution to implementation of a given process, it may provide only partial coverage of the criteria.

ANNEX IV. LIST OF TYPICAL EXPERIMENTS PERFORMED AT SIX DIFFERENT RR FACILITIES

Educational experiments and practical training at Research reactors
An example based on EERRI experience prepared by L. Sklenka, CTU in Prague, 2010

R - Routine experiment - is perform anytime without any special preparatory works
A - Advance/non-routine experiment - doesn't perform anytime, needs preparatory works
U - Under-construction experiment - expected utilization in next 12 month
C - Considered/planned experiment - planned utilization in next 2-3 years

Training Experiment	RR ...	RR ...	RR ...	RR ...	RR ...	RR ...
Reactor control - practical experience	R	R	-	R	R	R
Critical experiment, approach to criticality:						
* full scale experiment - duration 2 weeks	A	-	-	-	-	-
* mock-up experiment - by fuel adding	-	R	A	C	R	A
* mock-up experiment - by moving rod	R	R	R	R	R	R
*	-	-	-	-	-	-
Reactivity measurements:						
* Positive Period method	R	R	R	R	R	R
* Source Jerk method	R	-	-	-	-	-
* Rod Drop method	R	-	-	A	-	-
* Source Multiplication method (Greenspan)	R	-	-	R	-	-
* Noise analysis (Rossi-Alpha methods,...)	C	-	-	A	-	-
* Digital Reactivity meter	C	-	R	-	-	R
*	-	-	-	-	-	-
Control rods calibration:						
* Inverse Count Rate	R	-	-	A	-	-
* Mutual Calibration method	R	-	-	-	-	-
* Positive Period method	A	R	-	R	R	-
* Rod Swap method	-	-	R	-	-	R
* Rod insertion method	-	-	R	-	-	R
*	-	-	-	-	-	-
Study of reactor dynamics:						
* zero power reactor with/without neutron source	R	-	R	R	-	R
* delayed neutrons detection	R	-	-	R	-	-
* thermal effects & coefficients	C	R	R	A	R	R
* void effects & coefficients	R	R	R	R	R	R
* power& thermal effects - pulse operation	-	R	C	-	R	C
* various materials impacts on reactivity	R	R	-	R	R	-
* reactor response to step reactivity changes	-	R	R	-	R	R
* Xe effect	-	-	-	-	-	-
* change of reflector effects	-	-	-	-	-	-
*	-	-	-	-	-	-
Basic reactor theory:						
* diffusion length & Fermi age in graphite	U	R	-	R	R	-
* diffusion length & Fermi age in light watter	U	R	-	C	R	-
* albedo & reflector effects in graphite	U	-	-	-	-	-
* albedo & reflector effects in polyethylene	U	-	-	-	-	-
* neutron source emission in manganese dilution	U	-	-	-	-	-
* photo-neutron sources (gamma, n) in berylium	U	-	-	-	-	-
*	-	-	-	-	-	-
*	-	-	-	-	-	-
Neutron detection:						
* neutron detection by gas detectors	R	R	-	R	R	-
* determination of gas detectors dead time	R	-	-	R	-	-
* neutron detectors properties for reactor I&C	R	R	-	U	R	-
* analysis of non-linearity for neutron detection	R	-	-	-	-	-
*	-	-	-	-	-	-
*	-	-	-	-	-	-
Neutron flux distribution measurement:						
* by gas detectors	R	-	-	-	-	-
* by activation detectors - folios	R	R	-	R	R	-
* by activation detectors - wires	R	-	-	R	-	-
* by Campbell's Method	A	-	-	U	-	-
* by compensated ionizing chamber	A	-	-	U	-	-
* by neutroncoax	-	-	-	-	-	-
*	-	-	-	-	-	-
Neutron activation analysis:						
* NAA - folios	R	R	-	R	R	-
* NAA - wires	R	R	-	R	R	-
* short-time instrumental NAA	R	R	-	R	R	-
*	-	-	-	-	-	-
*	-	-	-	-	-	-
Gamma studies:						
* gamma fields measurement by NAA	R	R	-	R	R	-
* gamma fields measurement by TLD	A	R	-	-	R	-
* gammaspectroscopy	R	R	-	R	R	-
*	-	-	-	-	-	-
*	-	-	-	-	-	-
Enviromental & health:						
* environmental biomonitoring	A	-	-	-	-	-
* fission products identification in the environment	A	-	-	R	-	-
* fissile isotopes determination by delayed neutrons	A	-	-	-	-	-
* I and Br detection in samples of thyroid gland	A	-	-	-	-	-
*	-	-	-	R	-	-
*	-	-	-	-	-	-
Radiation protection:						
* radiation monitoring in reactor hall	R	R	R	R	R	R
* personnel monitoring	R	R	A	R	R	A
* monitoring of environment	-	-	-	-	-	-
* surface decontamination training	A	R	-	A	R	-
* fuel leakage testing	-	-	-	R	-	-
*	-	-	-	-	-	-
Reactor operation:						
* practical training in physical protection	-	A	A	-	-	-
* practical training in emergency preparedness	A	-	-	-	A	-
* practical training in emergency exercise	A	-	-	-	A	-
* practical training in fuel management	-	A	-	A	-	-
* practical training in rad.waste management	-	A	-	A	-	-
* practical training in water chemistry	-	-	R	-	-	-
* practical training in maintenance programs	A	R	-	R	-	R
* practical training in inspection programs	A	R	-	R	-	R
*	-	-	-	-	-	-

ANNEX V. MEETING AGENDA

Consultancy Meeting on Regional Research Reactor Coalitions and Centres of Excellence to Enhance Availability, Utilisation and Support to Newcomer States Planning NPPs

13-16 October 2010
Czech Technical University, Prague, Czech Republic

Wednesday, 13 October 2010

08:00-09:00	**Registration**
09:00-09:45	**Welcome & Opening Remarks** **Prof. Miroslav Čech,** Dean, Nuclear Sciences & Physical Engineering, Czech Technical University **Mr Lubomir Sklenka** (Czech Technical University) **Mr Danas Ridikas** (Scientific Secretary, Research Reactor Officer, IAEA) Self introduction of the participants; Selection of the Chairperson & Rapporteur Approval of the Agenda, Discussion & Administrative Arrangements
09:45-10:30	**Mr Danas Ridikas**, IAEA: Introduction & Objectives of the Meeting
10:30-11:00	*Coffee break*
11:00-12:30	**Mr Herman Roberto BLAUMANN,** CNEA, Argentina **Mr Guido VITTIGLIO,** SCK*CEN, Belgium
12:30-14:00	*Lunch break*
14:00-15:30	**Mr Lubomír SKLENKA,** CTU, Czech Republic **Ms Jitka ZAKOVA/Mr Janne WALLENIUS,** KTH, Sweden
15:30-16:00	*Coffee break*
16:00-17:30	**Mr Francois FOULON,** INSTN, France **Summary Discussion**
19:00	**Hospitality Event**

Thursday, 14 October 2010

09:00-10:30	**Mr Abdelmajid ÇAOUI,** CNESTEN, Morocco **Mr Nguyen Trung TINH**, EPU, Vietnam
10:30-11:00	*Coffee break*
11:00-12:30	**Ms A. Beril TUĞRUL**, EI/ITU, Turkey **Mr Steve REESE**, Radiation Centre/OSU, USA
12:30-14:00	*Lunch break*
14:00-15:30	**Discussion: Enhanced Role of RR in the Centre for Nuclear E&T** **Discussion: Drafting of conclusions & recommendations**
15:30-16:00	*Coffee break*
16:00-17:30	**Discussion: Regional Concept of the RR Network in the area of E&T** **Discussion: Drafting of conclusions & recommendations**

Friday, 15 October 2010

09:00-12:30	**Technical Tour to RR facilities in Rez (near Prague)**
12:30-14:00	*Lunch break, back to Czech Technical University in Prague*
14:00-15:30	**Technical Tour to RR facilities in Prague**
15:30-16:00	*Coffee break*
16:00-19:30	**Discussion: Finalizing of conclusions & recommendations** ***End of the Meeting***

ANNEX VI. LIST OF PARTICIPANTS

Consultancy Meeting on Regional Research Reactor Coalitions and Centres of Excellence to Enhance Availability, Utilisation and Support to Newcomer States Planning NPPs

13-16 October 2010
Czech Technical University, Prague, Czech Republic

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Photo of Meeting Participants