National Consultants’ Meeting on Development & Harmonization of Curricula on Research Reactor Experiments & Courses

Report of a Workshop under regional TC project RAF4022

Algiers, Algeria, 6-9 May 2012

NOTE

The material in this document has been supplied by the authors and has not been edited by the IAEA. The views expressed remain the responsibility of the named authors and do not necessarily reflect those of the government(s) of the designating Member State(s). In particular, neither the IAEA nor any other organization or body sponsoring this meeting can be held responsible for any material reproduced in this document.
CONTENTS

1. BACKGROUND ......................................................................................................................... 1
2. OBJECTIVES OF THE WORKSHOP ......................................................................................... 1
3. WORK DONE ............................................................................................................................. 1
4. EXECUTIVE SUMMARY ........................................................................................................... 7
5. CLOSING ..................................................................................................................................... 9

ANNEX I. MEETING AGENDA ...................................................................................................... 10

ANNEX II. INDIVIDUAL COUNTRY INTERESTS .......................................................................... 12

ANNEX III. LIST OF PARTICIPANTS ............................................................................................ 13
1. BACKGROUND

Some AFRA Member States have or are committed to have nuclear research reactors (RRs) for education and training, neutron science and technology, radioisotope production and other industrial applications. In most of these countries, RR is also seen as a stepping stone to develop a national nuclear energy program. In this context, there is a lack of skilled and trained personnel in the field of nuclear technologies, where RR may play the primary role in human resource development as part of a broader approach for the development of required nuclear infrastructure. The meeting aimed to address issues related to human resources development using RRs in the areas of applications, utilization, and management of RRs. In particular, this meeting intended to give the opportunities, at the regional level, to evaluate the needs and prepare the necessary skilled personnel in the areas of nuclear technologies, including (but not limited to) nuclear energy, both for operating and regulating authorities. Special emphasis was to be given to the development of a road map on harmonization of curricula on RR experiments and courses within the African region, taking into account good practices and lessons learned from other facilities/regions.

2. OBJECTIVES OF THE WORKSHOP

The objectives of the meeting were to provide the AFRA participants with the practical information regarding the establishment and implementation of a strategy for human resources development using RRs, including methodologies to assess training needs in the participating Member States as well as communicate lessons learned and good practices from other regions. In particular, issues regarding development, harmonisation and share of curricula on RR experiments and courses were to be discussed. The workshop also aimed to provide a forum to exchange information, share knowledge and experience on different practical aspects of establishing and implementing training courses using RRs for human resource development, including countries without RRs.

In addition to presentations from the IAEA representatives on the objectives and expected outputs, the meeting also included external expert presentations as well as presentations from the participants on the national needs of human resources development using RRs and the associated regional activities proposed to be implemented within the project. In detail, the meeting structure included:

- Topic-related presentations from IAEA representative(s)
- Nuclear education and training related presentations from external experts
- Presentations from the participants on their needs for human resource development, examples of existing/planned academic curricula including RR experiments
- Working group sessions on situation in the participating organizations regarding E&T using RRs and strategy (road map) for future development, including regional cooperation.

Input required prior to the meeting by all participants: reply to the specific IAEA questionnaire.

3. WORK DONE

This workshop was organized under the IAEA regional Technical Cooperation project RAF4022 “Enhancing Research Reactor Utilization and Safety (AFRA)”. The meeting was attended by 20 participants from 11 Member States in Africa, including two international experts from Czech Republic and France. The meeting was opened by Mr Salhi, the host representative of organizing committee of the meeting. Right after followed welcome addresses by the Director General of Centre de Recherche Nucléaire de Draria (CRND) and Director General of Centre de Recherche Nucléaire de Birine (CRNB). Mr D. Ridikas, IAEA representative and technical officer of the RAF4022 project, subsequently welcomed the participants, thanked the hosts and introduced the International Experts, namely Mr F. Foulon (France) and Mr L. Sklenka (Czech Republic). This was followed by a self-presentation of the participants (see details in Annex).
Right after followed a brief presentation by Mr D. Ridikas (IAEA) on issues and challenges in the area of RR utilization and applications, specific region background and main objectives of the meeting. In brief, Mr Ridikas presented the Agency’s observation that the number of operational RR is decreasing and still about half of all RRs remain underutilized while, as a paradox, there are some requests by newcomers to start the first RR project in the respective country. The main reasons for underutilization are lack of strategy, insufficient budgets, lack of pro-active actions and motivation, and insufficient quality assurance implementation. Mr Ridikas explained the importance in establishing a strategic planning to improve such situation. He explained that the Agency assists Member States in this process through different actions: IAEA cross cutting activities on RRs, IAEA RR Database that includes application oriented functions, Regional TC project such as RAF 4022, various forms of support and assistance for the newcomers. Other activities include: development of strategic & business plans, promotion and support of RR Networks and Coalitions and, finally, development of Internet Reactor Laboratory. Mr Ridikas also emphasized on the role of RR in the context of national NPP programme at all stages of the project: planning, building and operation. This last item was directly linked to the objectives of this meeting.

Mr Foulon (France) gave an introduction on the general need for E&T for nuclear programs, with reference to the IAEA safety standards and to various reports on education and training employed in this area in Europe. He outlined that it has been identified that Education and Training being of particular importance for nuclear energy in the EU, making it part of the 7 Flagship Initiatives of the European Commission for the Europe 2020 strategy. Mr Foulon, also outlined that each country has its specific needs in E&T according to its nuclear programme, therefore, each country has to define its own E&T programme with the objective of ensuring the safe operation and maintenance of their nuclear facilities. Mr Foulon also indicated that “effective cooperation in the area of nuclear E&T between industrial and regulatory organizations, and academic and research institutions has been very valuable in stabilizing nuclear education programs and in their reorientation towards future needs”. Mr Foulon presented in detail the E&T activity of the ISIS Research Reactor located at CEA Saclay and mentioned that E&T is its main activity since 2007. He also presented the details of various experiments and training courses that are carried out employing the reactor, as well as the E&T programmes in which the training courses are integrated. This included examples of both academic programmes and continuing education programmes for professionals. Mr Foulon gave some details about the pedagogical and practical aspects to be taken in account for the organization of training courses on a small power RR. He also presented some further development of the E&T programs that can take advantage of distance learning technique that can include Internet Reactor Laboratory.

Mr Sklenka (Czech Republic) in his first talk presented a general overview of nuclear education at RR focusing on what has been developed on Training Reactor VR-1. His presentation contained a lot of practical suggestions and guidelines on how to establish effective educational process at a low power RR. The talk was focused on five main topics – potential reactor users in education; typical reactor experiments for nuclear education; various examples of experimental equipment and methodologies for education; the basic conditions for education; and finally, several practical examples from the VR-1 Reactor (training at the RR was a topic of his second presentation). Mr Sklenka emphasized that education at RR is suitable for students at all academic levels (Bachelor, Master and PhD) but that it is necessary to adapt educational process to the initial level of students from various study programmes (nuclear engineering, power engineering, natural sciences, medical sciences, physical sciences, etc.). Education at RR is a specific discipline different from R&D. Indeed, it needs specific approach and dedicated efforts, particularly for BSc and MSc students where special educational instrumentation (easy to use) is needed and where the study of one specific phenomenon at a time is targeted. For effective education, the power of RR is not a limiting factor and someone who wants to initiate educational programme at RR does not need expensive equipment to achieve appropriate pedagogical results. Lot of inspiration can be brought looking at the history of reactor experiments in 50s and 60s, when the first reactor experiments were performed.
Mr Foulon, during his second presentation, described a number of practical examples and requirements for RR based E&T courses. This included the methodology used for the development of the E&T activity on a RR. Starting from the pedagogical objectives, the reactor capabilities and the need for technical or administrative modifications have to be explored. Mr Foulon gave the example of the transfer of E&T activity from ULYSSE to ISIS RR that was conducted at CEA Saclay from 2004 to 2007. This transfer lead to the refurbishment of the control system, the modification of the layout of the control room, the development of a supervision system, the modification of the safety documents and of the reactor license. When developing training courses on a RR, Mr Foulon also stressed the need to take into account other concerns such as financial, technical and organizational aspects. Starting from the experiments and training courses that are carried out on ISIS reactor, Mr Foulon gave detailed examples of curricula that have been developed for MSc students and engineers in Nuclear Engineering, for operators of RRs, as well as for specific E&T programmes that have been defined on request to meet the specific needs of the nuclear energy programmes (managers, train-the-trainers, …). For each curriculum the exact content of the course was given outlining the pedagogical method that was used to achieve the objectives of the course.

Mr Sklenka, in his second talk, focused on training at the RR and pointed out the principal differences between education and training at RR by presenting several practical examples and requirements for training courses at RRs. He presented several typical targeting groups of professionals like NPP operators and reactor core physicists, RR staff & researchers, regulatory body inspectors, nuclear safety experts, health physicists, radiation protection workers, etc. Mr Sklenka emphasized that various types of training exist (face-to face training, simulators and hands-on training at RR) being all complementary and necessary for effective training, since customers expect complex services in order to save their budget, participants’ time and efforts, and to allow participants to concentrate only on training without any disturbing influences. In the next part of his talk, Mr Sklenka presented three examples of training at VR-1 Reactor - for NPP operators and core physicist from Czech Republic (initial training); for NPP reactor physicists from Slovakia (re-training); and for inspectors from Czech regulatory body (train-the-trainers course). At the end of his presentation, Mr Sklenka focused on standardization of training courses, on ways to effectively communicate with the customers and how to measure effectiveness of the training (for example using pre-test; post-test; periodic weekly tests; and/or questionnaires).

The second day of the meeting started with the IAEA experts (Mr Sklenka and Mr Foulon) preliminary analysis of the first round of questionnaire results on education and training at research reactors in Africa. This questionnaire was prepared in advance and was sent to the RAF4022 participating countries prior to the meeting. Out of 16 questionnaires distributed to African countries, 9 countries sent back filled questionnaire (56 %) 1 country sent back old questionnaire (6 %) and 6 countries have not replied yet (38 %). Questionnaire was divided into four parts. The first part was focused on country overview in nuclear capabilities and needs. Real needs and potential capabilities were identified. The second part of the questionnaire was focused on capabilities and needs in theoretical nuclear education (e.g. academic education). It was recognised that 35 subjects from 36 listed in questionnaire are part of a typical national education system at BSc, MSc or PhD level. The last subject “Material structure studies” was recognized as a need but without any appropriate capabilities in African countries that provided replies to the questionnaire. The third part of the questionnaire was focused on capabilities and needs in practical education at RR (e.g. reactor experiments). It was recognised that 31 subjects from 34 listed in questionnaire are part of a typical national education system at BSc, MSc or PhD level. The last three subjects: “Boron neutron capture therapy”; “Material structure studies”; and “Geochronology” was recognized as a need but without any appropriate capabilities in African countries. The last part of the questionnaire was focused on current or future status and needs of the reactor experiments and more detailed information about it. It was recognised that 12 groups of experiments from 13 listed in questionnaire are groups of experiments performed at African RRs at certain level (from very limited and preliminary level up to routine experiments). The discussion which followed the preliminary analysis clearly shows that, even some subjects (both theoretical education and reactor experiments) are part of curricula in some African countries, there is a clear need to improve or enhance most of them. Concerning the way the
questionnaire was filled, the experts expressed the need to know from the countries the procedure that was used to fill the questionnaire (how many persons and which organizations involved at national level). Following this analysis, a round-table discussion took place. Mr. Ridikas indicated that once IAEA gets the answers of all countries there would be a clearer picture of the needs and capabilities of AFRA countries. He stressed that according to the preliminary analysis, the potential concerning E&T at RR is there and can now be better developed and used. In addition, he indicated that if all countries would agree on the final document, the needs and capability of each country (nominative) could be used as a regional database to be shared by all countries. Mr. Reguigui (Tunisia) asked to add to the questionnaire the information about the contact information in order to get a better efficiency of the database. Mr Mkilaha (Tanzania) expressed the difficulty that can be encountered filling the form globally for a country taking into account the capabilities and needs of all organizations and institutions. It was emphasized by the experts that the questionnaire is a starting point of establishing clear national/regional strategy related to E&T programmes involving RRs.

Mr Salhi (Algeria) presented the potentials and objectives of E&T using Algeria RRs.. This included a short presentation on the two Algerian RRs (NUR MTR – 1 MW and Es Salam MHWR- 15 MW) and their utilization in manpower development and training, NAA, Neutron scattering, Neutron imaging and R&D on radioisotopes. Mr Salhi indicated that the council of ministers has granted the creation of the Algerian Institute of training in nuclear engineering whose mission will be the development of human resources in nuclear engineering, radiological sciences and health physics. Mr Salhi presented the different fields of application of the RRs for vocational training, on the job training and training by research. Concerning the academic programs, every year about 30 students attend training courses (duration from 2 days to 2 weeks) on RRs. In complement to Mr Salhi’s presentation, Mr Saichi (Algeria) presented the capabilities of the Algeria RRs in training experiments, detailed some of the routine exercises done in the two Algeria RRs like reactivity measurement, control rod calibration, neutron flux measurement, etc. This was completed by an overview of the important applications using the Algeria RRs.

Mr Luyindula Ndiku (DR Congo) presented the status of nuclear E&T in DRC, including the needs in nuclear education for the accomplishment of the National nuclear programme, which was defined in the Nuclear Knowledge Capacities building Ordinance No. 78-195 from May 1978, and for the HR development. He presented the career opportunities in the nuclear field which include applications of radiotracers in industry (petroleum, cement and mining industry) as well as radiotherapy centres. Mr Luyindula Ndiku presented the details of the nuclear training programmes that are carried out by 4 institutions: University of Kinshasa (at BSc, MSc and PhD levels), National Pedagogic University, Institute of Science & Applied Techniques and Institute of Science & Medical Techniques (BSc level only, for the three latter institutions). At BSc level, in total more than 800 diplomas per year are dealing with Nuclear Science. MSc level is achieved by about 10 students per year in 2009 and 2010. Mr Luyindula Ndiku presented the nuclear activities of General Atomic Energy Commission (CGEA) and University Hospital of Kinshasa. A detailed presentation of the missions and facilities of CGEA was given. Courses on radiation protection are regularly carried out since 2001, leading to the E&T of around 15 persons every year in the period 2010-2012. It has to be pointed out that the Triga Mark II reactor is shut down since 2004, originally due to the failure of a period measuring module. In 2009, there was a government commitment to support the RR restart and work is under progress for facility restart following the recent INSARR mission. Mr Luyindula Ndiku concluded his presentation indicating that RR applications are expected to contribute to DRC Industry, E&T, R&D and general socio-economic development. He expressed the need for an assistance of IAEA for expertise, human resource development and procurement of equipment.

Mr Gaheen (Egypt) presented the E&T activity using ETRR-2 reactor (22 MW), starting with an overview of reactor characteristics related to E&T activity. He presented the list of experiments that can be carried out on the reactor and that are integrated in E&T programmes related to reactor physics, nuclear physics, radiation protection, instrumentation and control. Mr Gaheen described the use of the RR for research opportunities, including design, construction, safety analysis, cold and hot tests, as well as codes and model validation. He presented the training programme of the RR personnel (6
months duration). The content of the course, the training methods, the training materials and the examination process were described. This included a more detailed description of the content of hands-on-training for operators and for radiological protection officers. In addition to initial training, retraining is also regularly carried out and training on request can be developed. The latter recently included “Instrumentation Training Course”, “Training and Education programme for AFRA Students at ETRR-2” and “Annual training for nuclear engineering student from Alexandria University (20 students for 1 week)”. Mr Gaheen indicated that the training material is commonly supplied in English. In conclusion, Mr Gaheen listed further experiments that could be installed on the reactor, such as data acquisition system for reactivity measurements and control rod calibration, noise analysis method for reactivity and kinetic parameters measurements, installation of BNCT and SANS experiments capabilities, completion of high pressure test loop for training of NPP operators. He expressed ETRR-2 interest and capabilities to play a role in the training of NPP operators.

Mr Gbadago (Ghana) presented the on-going activities in E&T and the associated needs. He presented the GHARR-1 reactor which is a 30 kW tank-in-pool reactor (MNSR) commissioned in 1995. The reactor would be converted to LEU by 2014. In addition to E&T, the reactor is used for NAA, as well as R&D in neutronics and thermal hydraulics. E&T activity is related to academic programmes, operation & maintenance, regulatory inspection, radiation protection & safety, physical protection, and safeguards. In addition, Mr Gbadago explained that Ghana Atomic Energy Commision (GAEC) in collaboration with the University of Ghana and the IAEA established a Graduate School of Nuclear and Allied Sciences (GSNAS) whose objective is to develop HR for Ghana’s nuclear industry and for the African region. In recent years, about 45 students attended GSNAS courses through IAEA support, including about 15 students from other African countries. In most of the programs offered by GSNAS, the RR is used, in particular for NAA, direct measurements and simulation using analytical codes. On the job training is done through attachment of students and sandwich program (6 month) with other institutions. Mr Gbadago expressed the need for assistance in the development of RR experiments, such as reactivity measurements, control rods calibration, study of reactor dynamics, basic reactor theory and neutron detection. He indicated that at this stage of the national programme, the first NPP could be expected by 2022.

Ms Ralaiarisoa (Madagascar) presented the nuclear education system in Madagascar. The presentation included the chart and objective of the National Institute for Nuclear Science and Technology (INSTN). INSTN has MSc programmes in Nuclear Physics and High Energy Physics. RR related courses are found both in these two MSc programmes as well as in newly established Undergraduate professional curricula. Presently, there are 25 students/year in MSc of nuclear physics and about 25 students/year are expected in the NDT programme when it starts. Ms Ralaiarisoa indicated that, theoretical courses are supported by practical courses at Madagascar-INSTN laboratories and by international collaboration (fellowships/training courses). There is a need for an extended use of RRs in the fields of E&T, radioisotope production, NAA and NDT, but at this stage Madagascar is not envisaging to embark on the acquisition of a RR, but rather to use the existing facilities in the region. Finally, Ms Ralaiarisoa indicated that following this meeting, the questionnaire will have to be updated.

Ms Nasri (Morocco) presented the mission statement of the National Centre for Nuclear Energy, Science and Technology (CNENSTEN) which included promoting nuclear applications. The CNENSTEN is the technical support unit of the national authorities and also responsible for preparation of the technological base of the nuclear power programme. She indicated that, under its law of establishment, the CNENSTEN “contribute to education and training of specialists needed for national nuclear power programme, and other areas using nuclear techniques. This includes about one thousand professionals and students who are trained per year. These E&T activities include programmes that are public oriented: schools, politics, even media. Ms Nasri gave a detailed list of the E&T activities that are carried out by CNENSTEN at National, Regional and International levels. She also presented the National and International partnerships on a general level and specifically in E&T. Mr El Younoussi (also Morocco) presented the Triga Mark II 2 MW reactor that was commissioned in 2009. Today, practical courses include: Reactivity measurement, Control rod calibration, Reactor power calibration.
and Neutron flux measurement. Further development of the educational capabilities of their RR is in progress. As stated by Ms Nasri, the objective of CNESTEN is to become a focal point domestically, regionally, and internationally for promoting nuclear safety, security, non-proliferation and peaceful applications of nuclear energy through training and exchange of information.

Ms Hamed (Sudan) presented the situation in Sudan concerning the nuclear E&T activity and needs, as well as the planning for the national nuclear programme. Sudan has no RR but is in the process of establishing its strategic planning. The nuclear programme is in three successive phases: a 30 kW RR (by 2015), a 5 MW RR a few years later and then the 1st NPP (beyond 2020). There is the need to establish an independent regulatory body and as such, the law is in its preparatory stages. Nuclear E&T programmes include: BSc in Nuclear Engineering (50 students), MSc in radiation protection (25 students) and MSc in nuclear science (25 students). The first batch of students graduated in Nuclear Engineering this year. Sudan is ready to activate regional network for E&T with Morocco, Algeria and Egypt.

Mr Mkilaha (Tanzania) presented Tanzania needs and on-going activities in E&T involving RR. Tanzania has no RR. It considers having one but there is no established plan yet. Important steps in the nuclear applications included the use of radiation for Medical and Health applications (since 1959), establishment of radiation Protection Act in 1983, Atomic Energy Act for regulation and promotion of Nuclear Technology in 2003. Nowadays, Nuclear Science and Technology Policy is in the final stage of development. Mr Mkilaha listed the Sectors in Tanzania in which nuclear technology applies. He described nuclear related E&T programmes that include: BSc, MSc and PhD in Nuclear Physics, MSc in Medical Physics, Diploma and BSc in Radiology and MSc in Oncology Training. He pointed out the limited financial and human resources, as well as the lack of up to date equipment and facilities to achieve the programme. Mr Mkilaha expects to overcome these limitations through capacity sharing by means of a Nuclear Science and Technical Centre. He listed limitations and needs concerning the different occupations: programmes established but low capacity for nuclear physicists, no local training for nuclear engineers and insufficient number of medical physicists who are trained abroad.

At this stage, Tanzania has collaborations with South Africa (E&T and experiments) and Ghana (E&T). Considering NPP programme Mr Mkilaha indicated that this is not a priority for the country at the moment (other alternatives for energy like hydro, coal, etc.) and that the need for NPP will be re-evaluated within the 2 next years.

Mr Reguigui (Tunisia) presented the 3 current key players in the nuclear field in Tunisia: the National Centre for Radiation Protection (CNRP), the National Atomic Energy Commission (CNEA) and the National Centre of Nuclear Sciences and Technologies (CNSTN). He focused on the history, human resources and fields of activity of CNSTN. Mr Reguigui listed the foreseen projects concerning the acquisition of a subcritical assembly (under IAEA TC project 2012-2016), a research reactor (feasibility study being carried out) and an ion beam accelerator (feasibility study being carried out). He indicated that the first RR is expected to enhance the country’s preparedness for the first NPP introduction, playing the primary role in educating and training the upcoming generations of nuclear engineers and scientists. The RR will also provide irradiation services in support of the Tunisian industrial, agricultural and health/medical infrastructure. The first NPP is planned to be operated around 2025. Human resource development is seen as a key issue for the NPP programme. A 10 year training programme has been established for E&T, starting from 2012. At national level, it includes two Engineering diplomas in Nuclear Engineering (20 to 40 graduates per year) and Instrumentation and control (15 to 30 graduates per year) and a graduate level to train scientists, researchers and trainers in all related nuclear fields (30 to 50 graduates per year). In addition, bilateral or regional cooperation play an important role in the E&T program. Thus today a lot of nuclear applications are carried out abroad in the frame of these collaborations.

In some additional presentations, Mr Sklenka presented the EERRI Group Fellowship Training Programme which was developed under IAEA request. The six weeks course is focused on participants mainly from non-nuclear countries, who wish to develop nuclear competence and infrastructure as a first step to develop a national nuclear power programme. The course is aimed at
young technical professionals with little or no nuclear experience who can work in future at research reactor licensee or at national regulatory body. Such a course could be good starting point for African countries who are seriously considering embarking on a nuclear power programme. In addition, Mr Sklenka presented curricula of typical academic course for BSc students which use reactor experiments at VR-1 Reactor in Prague.

Mr Reguigui (Tunisia) gave a short and comprehensive presentation about AFRA educational and training activities. AFRA has established a High Level Steering Committee (HLSC) for the implementation of education and training programmes which could be one of the potential sources of experts and funds for extension and enhancement of the nuclear education in Africa.

Mr Saichi (Algeria) made a presentation on the Training of Operating Personnel at Nur and Es Salam RRs. After a brief presentation on the two facilities, he described the specific training programme approach that takes into account the different positions in the operating chart and that includes theoretical and practical training, on the job training and occupational duties. Mr Saichi presented in detail the operator syllabus that corresponds to about 700 hours of education and training over 9 month to be completed by a sequence of 4 months under occupation of duty. The details of the experiments carried out on RRs were also given. The implementation, including the recruiting process, and the evaluation of the training programme were also described. Finally, the continuing training process was also discussed.

Mr Mazidi (Algeria) made a presentation on a simulator that can be used for the determination of the thermal hydraulic and neutronic parameters (Automated Thermal Hydraulic and Neutronic Analyser SYStem – ATHNA.SYS). The code developed has been validated for NUR reactor. The simulator can be used on-line (directly receives the parameters from RR control room) and off-line (independent from RR control room) and can be used in the frame of RR operation, core design and modification, safety report up-date, training of staff and students in RR core physics and engineering. Mr Mazidi indicated that this simulator could be adapted for use in other facilities and expressed the potential for cooperation in this field.

Last but not the least, the technical tour to the NUR research reactor and its facilities was organized. This event was highly appreciated by the meeting participants, who had a possibility to learn more about utilization capabilities by visiting different instruments and laboratories associated with this RR facility.

4. EXECUTIVE SUMMARY

As a result of round table discussions and concluding session, the following resumes the output of the meeting.

Conclusions:

- Meeting was a useful and timely event; the main objectives have been achieved; need for such a meeting was confirmed and appreciated
- Preliminary analysis of the questionnaire filled by 9 countries shows that African countries have a big potential in terms of experiments that can be carried out on regional basis in order to develop the human resources using RR facilities. However at this stage, African countries expressed their need for further assistance to develop education and training courses, ensure their quality and standardization using RRs
- Analysis of the questionnaire and discussions that took place has shown that for most countries the questionnaire has to be reviewed and further improved/completed. A finalized comprehensive document (with the contribution of RAF4022 countries) could then be shared and used as a base for the development of the regional road map for nuclear E&T involving RRs
- It has been confirmed that the questionnaire is a first important step in defining the needs and identifying existing capabilities of each country. It needs to be used in parallel with a strategic
plan that would identify the stakeholders, the objectives and actions to be taken towards implementation of coherent strategy related to nuclear E&T involving RRs

- Participants expressed their concern about the lack of funding they are facing regarding the participation of students or professional staff to RR E&T courses that are proposed within the region or at an international level. Development of alternative teaching techniques that could reduce the accommodation and travel expenses was encouraged (e.g. internet RR laboratory)

- E&T programs, using the national RRs, exist in different RAF4022 countries (e.g. Algeria, Egypt, Ghana, and Morocco). Although open to Member States, these programmes are mainly organized at national level. Content of these programmes, contact information, other modalities are not available or difficult to find

- Meeting participants expressed their need to have standardized academic programme and training course curricula. Experts indicated that programme and curricula are highly connected to the need of the various stakeholders, so only general trends or typical examples can be provided, while specific courses should be designed based on the targeted trainers/trainees to be trained

- Good practices which were presented during the meeting in the field of training of RR operating staff in Algeria is a good example of successful collaboration between two different RRs leading to their mutual benefit. This collaboration could be an inspiration for AFRA regional collaboration and networking in the field of E&T at RRs

**Recommendations:**

- IAEA: follow up on recommendations of this workshop, and continue this project
- AFRA: promote and support a dedicated programme in nuclear E&T using RRs
- IAEA: need for E&T efforts related to advanced modelling and code application related to RRs (incident/accident situations); follow up on active CRP of RR benchmarks
- IAEA & AFRA: support and implement train-the-trainer concept with emphasis on non-RR countries, improve E&T capabilities to perform training locally within the region (e.g. proposal and support for a new regional TC project dedicated to this issue)
- IAEA & AFRA: assist in market evaluation and development; should lead to increased utilization and sustainability of RRs; need for strategic planning and periodic performance monitoring
- IAEA: support and implement on request EMs (for RR facilities) to review and advise on E&T using RRs
- IAEA & AFRA: assist to arrange bilateral agreements and cooperation through recent TCDC concept as a new component of the regional strategy
- IAEA & AFRA: initiate, support and implement internet RR laboratory project (for countries without RRs, provided by countries with RRs)
- IAEA: design and implement regional training course (e.g. annual summer school) related to E&T using RRs; still within train-the-trainer concept (e.g. through new regional TC project)
- All: IAEA questionnaire has to be completed/reviewed by all RAF4022 countries in order to establish a final document that could be shared by all interested parties; should be used as part of strategic planning process
- All: call for broad and active participation in next AFRA RR Conf. in October, in Cairo, Egypt, followed by RAF4022 PC meeting (deadline for nominations and abstract submission 1 July 2012)
- National governments: encourage follow up and implementation of agreements and engagements made by national consultants; seek for timely feedback and proactivity
- National governments: support and contribute to organization and implementation of RR related summer schools and other nuclear E&T activities involving RRs
- National governments: newcomer countries are encouraged to initiate nuclear engineering programmes (with specific component using RRs and associated facilities for hands-on-training) at their universities in case of plans to embark on NPP projects as part of their CPF
Joint work-plan for the next 12 months:

- Provide typical full courses/programmes of Nuclear Engineering (curricula); IAEA + Experts; 15 June 2012
- Finalize and make available the IAEA questionnaire on E&T using RR; All; 15 July 2012 for return and September for joint distribution
- Analyse them and prepare/share during AFRA RR Conf.; IAEA + Experts; October 2012
- Collect and make available the curricula of existing courses, involving RR (at least one per operating RR, can be more if available); template is provided; Countries with RR; 15 July 2012
- Initiate internet reactor project: well developed/accepted institution as provider + non-RR as a recipient; IAEA + selected partners; ASAP
- Organize next national consultants’ workshop on “Practical demonstration and standardization of RR experiments” of 5 days in 2013: will include 2 days for demonstration experiments (4 experiments) + lectures + 2-3 days for workshop; IAEA + Experts + selected RR country
- Propose a tentative design (scope, duration, contents) of the train-the-trainer regional course using RR; IAEA + experts + consultation of some RR facilities; October 2012 and to be discussed in PC meeting in Cairo; IAEA+Experts

5. CLOSING

The participants concluded that the workshop was a very successful and well organized event. Mr D. Ridikas (IAEA) thanked the representatives of Algeria for hosting this event, for organizing technical tour to NUR RR facility and for their kind hospitality during the meeting. He also thanked all 9 Member States + 2 External Experts for their active participation and contribution in achieving the expected results of the workshop.
ANNEX I. MEETING AGENDA

Sunday, 6 May 2012

09:00 – 09:30 Welcome and Opening Remarks; COMENA and IAEA representatives
Self presentation of participants, administrative issues
Presentations and round table discussions facilitated by the IAEA Experts

09:30 – 10:00 D. Ridikas, IAEA
Background & Objectives of the Meeting

10:00 – 11:00 F. Foulon, France
Share of good practices & lessons learned in nuclear education & training
based on small power RR at CEA Nuclear Research Centre

11:00 – 11:30 Coffee break

11:30 – 12:30 L. Sklenka, Czech Republic
Share of good practices and lessons learned in nuclear education & training
based on small power RR at Czech Technical University

12:30 – 14:00 Lunch time

14:00 – 15:00 F. Foulon, France
Practical examples and requirements for RR based E&T courses:
I. Curricula for training of MSc students and Engineers in nuclear engineering
II. Curricula for training of RR operators
III. Curricula for training specifically developed on request (e.g. managers, train-the-trainers)

15:00 – 15:30 Coffee break

15:30 – 16.30 L. Sklenka, Czech Republic
Practical examples and requirements for RR based E&T courses:
IV. Curricula for training of NPP operators
V. Curricula for training of safety and regulatory authority staff
VI. Curricula for training specifically developed on request (e.g. non-nuclear engineering
students)

16:30 – 17.00 Discussion, summary & conclusions of the 1st day
18:00 Hospitality Event

Monday , 7 May 2012

Analysis of the IAEA questionnaire

09:00 – 10:00 L. Sklenka, Czech Republic & F. Foulon, France
Status and future road map in E&T courses involving RRs in Africa
Country Reports by National Consultants:
needs and on-going activities in E&T involving RRs

10:00 – 11:00 Algeria & DRC (30 min each)
11:00 – 11:30 Coffee break
11:30 – 12:30 Egypt & Ghana (30 min each)
12:30 – 14:00 Lunch time
14:00 – 15:30 Madagascar, Morocco & Sudan (30 min each)
15:30 – 16:00 Coffee break
16:00 – 17:00 Tanzania & Tunisia (30 min each)
17:00 – 17.30 Discussion, summary & conclusions of the 2nd day
**Tuesday, 8 May 2012**

**Round Table Discussion by All**

09:00 – 11:00  Status and future road map in E&T courses involving RRs in Africa;  
**Drafting of summary** related to needs, requirements and joint interests  
11:00 – 11:30  *Coffee break*  
11:30 – 12:30  Status and future road map in E&T courses involving RRs in Africa;  
**Finalizing of summary** related to needs, requirements and joint interests  
12:30 – 14:00  *Lunch time*  

**Host lecture and Technical Tour**

14:00 – 15:00  Host lecture on E&T activities involving RRs in Algeria and introduction to the technical tour  
15:00 – 16:00  Technical tour to the NUR RR and related auxiliary facilities  
16:00 – 16:30  *Coffee break*  
16:30 – 17:30  Discussion, summary & conclusions of the 3rd day

**Wednesday, 9 May 2012**

**Round Table Discussion by All**

09:00 – 11:00  Design of a “typical” course, including requirements, based on RR and as part of university programme curricula  
11:00 – 11:30  *Coffee break*  
11:30 – 12:00  Formulation and drafting of  
✓ workplan and actions matrix  
✓ conclusions and recommendations  
12:30 – 14:00  *Lunch time*  
14:00 – 15:30  Finalization of  
✓ workplan and actions matrix  
✓ conclusions and recommendations  
15:30  *Coffee break*  

**End of the meeting**
ANNEX II. INDIVIDUAL COUNTRY INTERESTS

1. Algeria:
   a. Exchange of experience on RR operators (related to implementing E&T programmes)
   b. SV on specific topic (noise analysis) to develop such course + necessary equipment
   c. Open to offer courses on request
   d. ...

2. DRC:
   a. National training course on safety, operation and maintenance of RR
   b. Commission and University: agreement on academic course accreditation
   c. NAA, radioisotopes
   d. ...

3. Egypt:
   a. Offer a specific course (basic and advanced) on E&T using RR
   b. Data acquisition of RR in order to be more equipped/adopted for training purposes (new TC project)
   c. Retrain the necessary staff (new TC)
   d. ...

4. Ghana:
   a. EM to Ghana on review of E&T courses using RR (new TC)
   b. Modernization of necessary equipment related to E&T courses (new TC)
   c. Regional offering of courses and training capabilities for the region
   d. NAA automation
   e. Various schools and training workshops...

5. Madagascar:
   a. Train the trainer in RR physics and applications
   b. Develop such courses locally afterwards
   c. Train PhD students to develop RR simulator

6. Morocco:
   a. Review jointly CNESTEN/University/Reg.body on needs for E&T related to RR
   b. Design and distribute questionnaire, update needs/capability matrix
   c. Review courses and associated needs to include RR in E&T process
   d. Follow up and open for joint activities...

7. Tunisia:
   a. 2 fellowships (RR topics)
   b. 2 SV on RR applications
   c. EM on basic RR physics
   d. Fellowship on modelling of reactor physics
   e. MSc student to be sent to the potential partner...

8. Sudan:
   a. Finalise national questionnaire, finish strategic plan
   b. Finalise and approve national law
   c. Nuclear engineering course (standard examples from France or Czech Republic)
   d. ...

9. URT:
   a. Nuclear Research & Technology centre establishment (local TC project)
   b. Cooperation with Korea, South Africa, Canada
   c. Follow up on Strategic planning and Milestones Document
   d. …
## ANNEX III. LIST OF PARTICIPANTS

| 1 | IAEA | Mr Danas Ridikas  
International Atomic Energy Agency  
Department of Nuclear Sciences and Applications  
Division of Physical and Chemical Sciences  
Physics Section  
A2302  
Vienna International Centre  
Wagramer Straße 5  
P.O. Box 100  
1400 VIENNA  
AUSTRIA  
Tel.: 0043 1 2600 21751  
Fax: 0043 1 26007  
EMail: D.Ridikas@iaea.org  
Internet: http://www.iaea.org |
|---|---|---|
| 2 | Czech Republic, expert | Mr Lubomir Sklenka  
Department of Nuclear Reactors  
Faculty of Nuclear Science and Physical Engineering (FNSPE)  
Czech Technical University (CTU)  
V. Holesovickach 2  
180 00 PRAHA 8  
CZECH REPUBLIC  
Tel.: 00420 2 21912390  
Fax: 00420 2 84680764  
EMail: lubomir.sklenka@fjfi.cvut.cz |
| 3 | France, expert | Mr Francois Foulon  
Institut National des Sciences et techniques nucléaires (INSTN)  
Commissariat à l’énergie atomique (CEA)  
B.P. 52  
91191 GIF SUR YVETTE CEDEX  
FRANCE  
Tel.: 33 1 69085430  
Fax: 33 1 69088173  
EMail: francois.foulon@cea.fr |
| 4 | Algeria | M. Mokhtar Abbaci  
Commissariat à l’énergie atomique (COMENA)  
Foresight studies and nuclear applications directi,  
2, boulevard Frantz Fanon  
B.P. 399  
16000 ALGER Gare  
ALGERIA  
Tel.: 00213 21 43 35 60  
Fax: 00213 21 43 35 39  
EMail: m.abbaci@comena-dz.org |
| 5 | Algeria | M. Said Djaroum  
Centre de recherche nucléaire de Birine (CRNB)  
Commissariat à l’énergie atomique (COMENA)  
B.P. 180  
17230 BIRINE, Djelfa  
ALGERIA  
Tel.: 00213 27872935  
Fax: 00213 27874280  
EMail: crnb@wissal.dz |
<p>| 6 | Algeria | M. Mohammed Mouzai |</p>
<table>
<thead>
<tr>
<th></th>
<th>Country</th>
<th>Name</th>
<th>Address</th>
<th>Phone</th>
<th>Fax</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Algeria</td>
<td>Mr Arezki Nedjar</td>
<td>Centre de recherche nucléaire de Draria (CRND) Sebala - Draria</td>
<td>00213 21 310175</td>
<td>00213 21 31038032</td>
<td><a href="mailto:m-mouzai@crnd.dz">m-mouzai@crnd.dz</a></td>
</tr>
<tr>
<td>8</td>
<td>Algeria</td>
<td>Mr Saichi</td>
<td>Centre de recherche nucléaire de Draria (CRND) Route de Seballa</td>
<td>00213 21 310358</td>
<td>00213 21 310380</td>
<td><a href="mailto:nedjar_arezki@yahoo.fr">nedjar_arezki@yahoo.fr</a></td>
</tr>
<tr>
<td>9</td>
<td>Algeria</td>
<td>M. M'hamed Salhi</td>
<td>Centre de recherche nucléaire de Birine (CRNB) Commissariat à l'énergie atomique (COMENA)</td>
<td>00213 27872921</td>
<td>00213 27 874280</td>
<td><a href="mailto:mn_salhi@yahoo.fr">mn_salhi@yahoo.fr</a></td>
</tr>
<tr>
<td>10</td>
<td>Egypt</td>
<td>Mr Talal Abou Elmarry</td>
<td>Egyptian Atomic Energy Authority (EAEA) 3 Ahmed El-Zomor Street</td>
<td>0020 2 44691755</td>
<td>0020 2 44691754</td>
<td><a href="mailto:Talal22969@yahoo.com">Talal22969@yahoo.com</a></td>
</tr>
<tr>
<td>11</td>
<td>Egypt</td>
<td>Mr Mohamed Abd El-Monem Gaheen</td>
<td>Egypt Second Research Reactor ETRR-2 Atomic Energy Authority (AEA)</td>
<td>0020 2 44691755</td>
<td>0020 2 44691754</td>
<td><a href="mailto:magaheen@yahoo.com">magaheen@yahoo.com</a></td>
</tr>
<tr>
<td>12</td>
<td>Ghana</td>
<td>Mr Joseph Korbla Gbadago</td>
<td>Department of Nuclear Engineering National Nuclear Research Institute</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ghana Atomic Energy Commission (GAEC) P.O. Box 80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Legon ACCRA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Country</td>
<td>Name</td>
<td>Address</td>
<td>Phone</td>
<td>Fax</td>
<td>Email</td>
</tr>
<tr>
<td>---</td>
<td>---------</td>
<td>-----------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>-------</td>
<td>--------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>13</td>
<td>Ghana</td>
<td>Mr Yaw Serfor-Armah</td>
<td>Department of Chemistry, National Nuclear Research Institute, Ghana Atomic Energy Commission (GAEC)</td>
<td></td>
<td></td>
<td><a href="mailto:yawserfor@yahoo.com">yawserfor@yahoo.com</a></td>
</tr>
<tr>
<td>14</td>
<td>Madagascar</td>
<td>Mme Haritiana Luciette Ralaiarisoa</td>
<td>Institut national des sciences et techniques nucléaires (INSTN), Radio-analytical and Nuclear Techniques, B.P. 4279</td>
<td></td>
<td></td>
<td><a href="mailto:hralaiarisoa@yahoo.fr">hralaiarisoa@yahoo.fr</a></td>
</tr>
<tr>
<td>15</td>
<td>Morocco</td>
<td>Mr Chafik El Younoussi</td>
<td>Centre national de l'énergie, des sciences et des techniques nucléaires (CNESTEN), reactor operating unit, B.P. 1382</td>
<td></td>
<td></td>
<td><a href="mailto:elyounoussi@cnesten.org.ma">elyounoussi@cnesten.org.ma</a></td>
</tr>
<tr>
<td>16</td>
<td>Morocco</td>
<td>Mme Bouchra Nasri</td>
<td>Centre national de l'énergie, des sciences et des techniques nucléaires (CNESTEN), PVR/CF, C B.P. 1382</td>
<td></td>
<td></td>
<td><a href="mailto:nasri7bouchra@yahoo.com">nasri7bouchra@yahoo.com</a></td>
</tr>
<tr>
<td>17</td>
<td>Sudan</td>
<td>Ms Afra Ahmed Hamed Ahmed</td>
<td>Sudan Atomic Energy Commission (SAEC), Ministry of Science and Technology</td>
<td></td>
<td></td>
<td>afr��<a href="mailto:114@gmail.com">114@gmail.com</a></td>
</tr>
<tr>
<td>18</td>
<td>Tunisia</td>
<td>M. Nafaa Reguigui</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 19 | United Republic of Tanzania | Prof. Iddi Suleiman Nyangarika Mkilaha  
Tanzania Atomic Energy Commission (TAEC)  
Njiro Area Block “J”  
P.O. Box 743  
ARUSHA  
UNITED REPUBLIC OF TANZANIA  
Tel.: 00255 27 25 08 554  
Fax: 00255 27 25 09 709  
EMail: mkilaha@gmail.com  
Internet: http://www.taec.or.tz |
| 20 | Democratic Rep. of the Congo | Dr Ndiku Sébastien Luyindula  
Département de microbiologie  
Commissariat général à l’énergie atomique (CGEA)  
B.P. 868  
KINSHASA XI  
DEMOCRATIC REP. OF THE CONGO  
Tel.: 00243 81 5186878  
Fax: 00243 8843675  
EMail: sluyindula@yahoo.fr |

Photo of Meeting Participants