The History and Evolution of the IAEA Technical Assistance Programme on Decommissioning and the International Decommissioning Network as its Highest Point-9000

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ABSTRACT

Around the world, but particularly in developing Member States, there are disused nuclear facilities or those approaching the end of their useful lives, for which appropriate decommissioning steps have not been taken, primarily due to limited technical and financial resources or competing priorities. In line with its mission to encourage safe and peaceful applications of nuclear energy, the International Atomic Energy Agency (IAEA) systematically covers the technical, regulatory, radiation protection, planning, management, and economic aspects related to the decommissioning of nuclear installations. The IAEA's overall objective of the decommissioning programme is to assist its Member States in developing the required expertise, equipment, and programmes so that they can decommission their nuclear facilities in a safe, timely, and cost-effective manner. Technical Co-operation (TC) with Member States having limited resources is commonly provided in the form of workshops, expert missions, equipment design and procurement, training courses, fellowships and scientific visits. Key examples are provided in this paper to illustrate the start, evolution and current status of TC activities and typical mechanisms by which such activities are implemented.

Many of world's nuclear facilities are small and widely distributed geographically, e.g. ~300 aging or shut-down research reactors. Requests for assistance to address this issue from Member States exceed the capability of IAEA (and others) to deliver. However, integrating individual initiative into a designed-for-purpose network may compensate for these limitations. A new IAEA initiative amongst organizations from both potential "donor" and "recipient" Member States has taken the form of an "International Decommissioning Network (IDN)".

The objectives of the IDN are to improve the flow of knowledge and experience amongst those engaged in decommissioning, and specifically to enhance the "user-oriented" focus for all IAEA decommissioning activities. The initial successes of the Network are expected to encourage contributions of organizations in the developed Member States to the activities of those in Member States requiring decommissioning assistance, and to maximize the benefit of TC activities through integration and improved measurability of results. The IDN provides a "bridge" between those Member States with specialized knowledge and those that need to apply it, and encourages an exchange of practical knowledge and skills. Links to other organizations with similar goals and interests, e.g. OECD/NEA, are being established.

INTRODUCTION

In line with its mission to encourage safe and peaceful applications of nuclear energy, the International Atomic Energy Agency (IAEA) systematically covers the technical, regulatory, radiation protection, planning, management, and economic aspects related to the decontamination and decommissioning (D&D) of nuclear installations. The IAEA overall objective of this programme is to assist its Member States in developing the required expertise, equipment, and programmes so that they can decommission their nuclear facilities in a safe, timely, and cost-effective manner. The IAEA programme on decommissioning includes two main areas. One is the development of standards, guidance, and collection

and dissemination of technical information all of which is published or made otherwise available to Member States. This is a form of indirect assistance. The other is the Technical Co-operation (TC) through which the IAEA directly assists Member States in the transfer of knowledge in the use of nuclear techniques. The first area is not further discussed in this paper which will focus on the technical co-operation with developing Member States. Technical co-operation with Member States is commonly provided in the form of workshops, expert missions, equipment design and procurement, training courses, fellowships and scientific visits, etc. A few examples are provided below to illustrate ongoing TC activities and typical mechanisms by which such activities are implemented. The paper also focuses on gradual changes in addressing assistance to Member States, beginning in early 1990s until the newly-launched International Decommissioning Network (IDN).

ORGANIZATION

In 1996, the IAEA separated the decommissioning programme into two distinct groups. The first group is the Waste Safety and Environment Section (WES) of the Division of Radiation and Waste Safety (NSRW). This section focuses on the safety of management and disposal of radioactive waste including decommissioning. The section is part of the Department of Nuclear Safety. The second group is the Waste Technology Section (WTS) of the Division of Nuclear Fuel Cycle and Waste Technology (NEFW), where the writer belongs. This section focuses on the technology available to support waste management activities and waste disposal. The section is part of the Department of Nuclear Energy. This separation of activities was instituted in order to keep the regulatory aspects separated from the promotional activities. In the day-to-day activities and programmes, the two groups are well-integrated in the execution of common activities which include technical co-operation, research and services to the Member States. It should be noted that the two groups are now programmatically merged. Besides co-operating with WTS in most of the activities mentioned below, WES has the driving role in a few specific activities, such as assistance to Iraq (see below).

TC PROJECT ON DECOMMISSIONING OF THE EWA REACTOR, POLAND

This project is a typical example of national TC project launched and implemented in mid-1990s. That was the time when quite a few research reactors came to a stage where further operation was made uneconomical due to ageing, international competition and lack of domestic resources. The EWA reactor is situated at Swierk near Warsaw and was operated by the Institute of Atomic Energy. EWA is a water-cooled and moderated WWR-S type, a Russian-design reactor in common use all over Central and Eastern Europe (CEE). It commenced operation in 1957 with a nominal power of 2 MW, gradually upgraded up to 10 MW in 1973. The reactor was permanently shutdown in February 1995.

When the TC project started in 1997, the operator has had the opportunity to work on the definition of a decommissioning strategy and draft a detailed decommissioning plan. In addition, extensive work had been performed on establishing a detailed radioactive inventory. In this respect it should be noted that the EWA reactor had been modified and upgraded a number of times. This enabled the activation of computer codes to be validated using materials removed during the modifications programmes, and sampling programmes. As the result, the EWA radioactive inventory was fairly clear. The basic features of the decommissioning strategy developed by the operator were as follows:

(i) Dismantling most of the systems and components external to the reactor block;
(ii) dismantling most of the reactor internals, including the thermal column, the beryllium reflectors, the core structure, the separator tank and the inner and outer tanks; and
(iii) retaining the reactor bioshield and the remaining systems in a safestore condition appropriate to possible future modification and re-use as a dry store for EWA and perhaps MARIA (another Swierk reactor) spent fuel.

The key factor influencing the choice of the EWA decommissioning strategy was associated with spent fuel management. Concerns exist in Poland regarding long-term storage of this spent fuel, some of which has been stored under water at least 20 years. According to the operator, reprocessing and other spent fuel management options proved either impractical or too expensive. A further consideration for the operator in selecting a strategy involving removal of most of the reactor internals was that the necessary skilled staff will only be available for a relatively short time. Therefore, the operator wished to complete as much decommissioning work as possible before commencing a period of safe storage. It should be noted that Poland has no nuclear power. Consequently, appropriate nuclear skills would be hard to find, for replacing any staff that retire from or leave the EWA reactor. Another factor allowing immediate dismantling of the EWA reactor was the reported capability of the Rozan waste repository to accept the reactor internals.

The IAEA experts acknowledged the basis for the decommissioning strategy that has been adopted by the operator. The TC project lasted until the year 2000 when most of the decommissioning work had been completed. Incidentally, the spent fuel was never stored in the reactor bioshield as international agreements on repatriation of Russian origin fuel made these prospects more attractive. Assistance to Poland was delivered in the form of ad-hoc expert missions (e.g. to advise on removal, conditioning and storage of beryllium waste) or procurement of equipment based on counterpart's needs. However, the overall planning and management remained at all times with the Polish operator. The EWA project was used for several years as a source of information for other national and regional projects. Currently an English translation of the EWA decommissioning plan is being prepared within the framework of an IAEA regional project for dissemination to other countries planning for or implementing the decommissioning of their research reactors (many of them similar to EWA) [1].

The EWA project was the precursor to a number of IAEA-assisted activities on decommissioning of nuclear activities, including among others, Bulgaria, Georgia, Latvia, Kazakhstan, Romania, Slovakia and Uzbekistan. Description of some of these activities is given in [2, 3]. Figs. 1, 2 give details of decommissioning activities carried out in Member States with the support of the IAEA. The number of countries involved in TC activities on decommissioning escalated from a few running in parallel in late 1990s until several dozen now (mostly under regional projects- see below).

Fig. 1. A-1 Decommissioning project, Slovakia: 3-D laser scanner

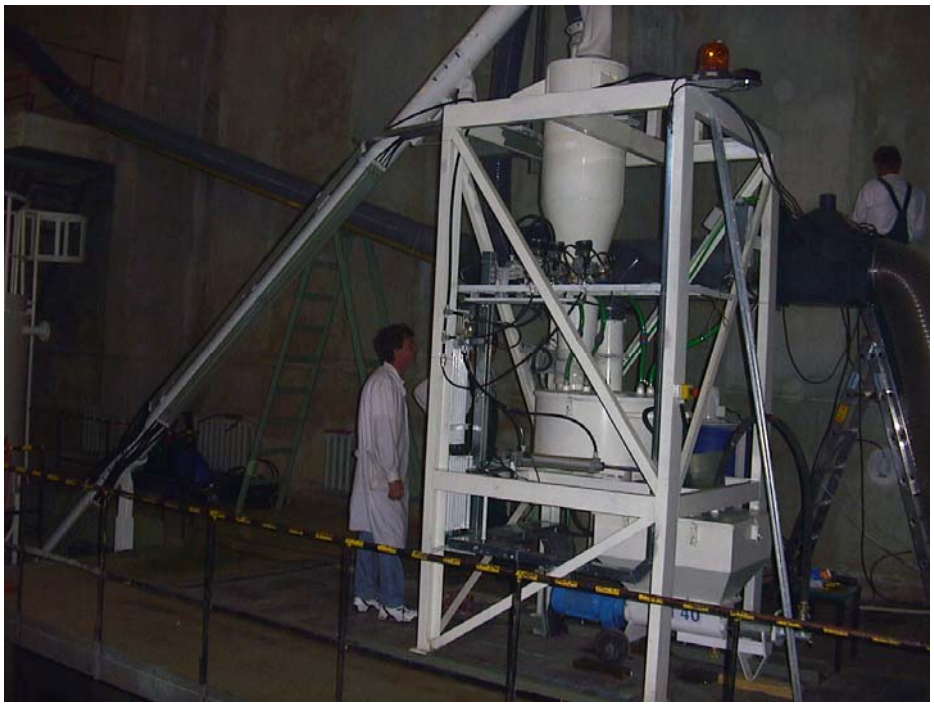

Fig. 2. Salaspils IRT reactor, Latvia, installation of the IAEA-procured cementation plant in preparation to decommissioning

REGIONAL PROJECT ON PLANNING FOR DECOMMISSIONING OF NUCLEAR POWER PLANTS AND RESEARCH REACTORS

In the late 1990s and early 2000s it was recognized that there were a number of common issues linking decommissioning projects in various geographical regions of the world. The first overwhelming example is CEE. Common factors include the following:

- Russian design (typically WWRs or IRTs);
- country's political history and socio-economic conditions (e.g. countries formerly part of the USSR block, then applying for and gaining admission to the European Union, NATO and other international organizations);
- lack of early plans or provisions for decommissioning and waste management;
- lack of decommissioning-oriented regulations;
- little or no experience/expertise in decommissioning;
- insufficient financial resources; and
- lack of awareness of and little priority given to decommissioning.

The project (RER/3/005), which started in 2005 and has a planned duration until 2009, but will presumably be extended further, addresses the drafting and expert review of NPP decommissioning plans or parts thereof in CEE. The project includes the organization of progress workshops and review meetings/visits to countries where decommissioning plans are being actively developed. The project called upon the expertise already gathered in the countries that have accumulated experience in decommissioning reactors, to provide advice to other countries where this experience is lacking. In addition to reviewers, the project makes good use of a committee including the IAEA Scientific

Secretaries, local counterparts subject to the review of their decommissioning plans, and other international experts. To date, it has been possible to implement the following mechanisms in parallel:

(a) Review of selected decommissioning projects/studies. This mechanism is ideally implemented when the NPP is subject to review or a given country in CEE is visited by the expert team under the regional project. To improve efficiency of the review process, the host country is requested to do homework and send relevant information to team members well before the review meeting. The scope and extent of the review depends on the information provided by the host country and follows given indications. Although informally conducted, this mechanism manages to create an active debate among committee members and, at least, highlight solutions to common issues in CEE countries. So far, the following countries have been involved: Armenia; Bulgaria; Croatia; Hungary; Russian Federation; Slovenia and Ukraine. Some of these countries requested review of their overall decommissioning strategies or plans; others focused on structure and main contents of decommissioning-oriented databases: others yet were interested in financial provisions for decommissioning.

(b) Progress reports. Countries that are developing decommissioning projects and studies are invited to present their progress achieved at periodic review workshops. From a complementary angle, similar presentations are given by reviewers and the overall project committee contributes to the discussion and provides orientation to further work.

(c) Discussions of specific topics. Such topics are assigned to specified experts from and/or outside the region. A list of a few subjects dealt with at dedicated project workshops is provided below:

(i) Selection of decommissioning strategy,
(ii) Pre-decommissioning radiological and physical characterization,
(iii) Establishment of a decommissioning database and record-keeping measures;
(iv) Drafting of preliminary decommissioning plans for operating reactors; and
(v) Cost assessment and funding.

One should note that such presentations are not to be given *per se* as a generic training tool, but only in support to countries' activities as conducted and reviewed within the TC project.

(d) Site visits. Visits are arranged to sites where NPPs, or research and development facilities, are located, and where active decommissioning projects are underway.

More recently, this regional project has been extended to research reactors.There is a broad range of research reactors in different stage of their lifecycle in Europe. It is expected that there will be an increasing number of research reactors closing down in the next few decades, and the associated decommissioning activities will require adequate planning, evaluation and demonstration of safety and appropriate measures for spent fuel and waste management. Planning is an important first step in decommissioning, which requires comprehensive and consistent consideration and evaluation of various factors (safety, technological, financial, social) in order to select an optimum decommissioning strategy (direct dismantling, deferred dismantling or entombment) of such facilities. Development of a decommissioning plan is required to be prepared by the licensee and approved by the regulatory body, as stated in Safety Requirements WS-R-5 [4] and Safety Guide WS-G-2.1 [5].

Although a significant number of older type research reactors do not have approved decommissioning plans, the importance of safety of decommissioning of research reactors has been recognized and emphasized at various international forums, such as the review meetings of the Joint Convention on the Safety of Spent Fuel Management [6]. Also in its March 2004 meeting the Board of Governors has

approved a Code of Conduct on the Safety of Research Reactors that encouraged Member States to ensure adequate planning and measures for decommissioning of these facilities.

A critical issue is that some research reactors remain in an undefined condition (neither operational nor permanently shutdown) for quite a number of years. Even for other reactors, where a decision for permanent shutdown is taken, still there are reasons (financial or others) that preclude timely and cost-effective implementation of decommissioning. The first step for IAEA assistance is to evaluate whether an adequate decommissioning strategy or plan is available. In those cases where the implementation of decommissioning plans is in place already, it will be also possible for the IAEA to assess the situation and provide advice if necessary.

THE RESEARCH REACTOR DECOMMISSIONING DEMONSTRATION PROJECT (R2D2P)

The Philippines national nuclear agency, PNRI, hosted the First Technical Meeting on Research Reactor Decommissioning Demonstration Project (R2D2P) from 26 to 30 June 2006 attended by seventeen (17) foreign delegates. R2D2P is a significant development from RER/3/005 and other national and regional events.

The Philippine Research Reactor-1 (PRR-1) is used as a demonstration facility for the series of technical meetings that will be held on this subject. R2D2P is in response to the perceived need of an increasing number of Member States whose research reactors have remained in a "state of limbo" due to lack of a decommissioning policy, expertise or the necessary funds to effectively implement decommissioning. The whole project aims to provide a platform for practical training in activities related to safe decommissioning, including aspects ranging from the establishment of a regulatory infrastructure for the regulatory body to the final release of the facility from regulatory control.

A R2D2P Workshop on the Transition Phase was held in Australia, on 12-16 November 2007.The Research Reactor Decommissioning Demonstration Project (R2D2P) was intended to be executed around the decommissioning activities carried out at the Philippine Research Reactor (PRR-1). As this reactor was shut down for repair and subsequently cleaned out it was not possible to demonstrate the transition from operation to decommissioning. Actually the fact that the High Flux Australian Reactor (HIFAR) was shut down at the beginning of 2007 and that it is in transition to “safe enclosure” provided a good opportunity to provide insight complementary to R2D2P and its PRR-1 model. Australian experts were instrumental to the lectures and demonstration of the HIFAR transition activities. They also provided a unique opportunity of including into the workshop schedule insight into the decommissioning of the MOATA reactor and to explain how the decommissioning was included into the design of the new OPAL reactor which went into operation in 2007. The scope of work necessary in the transition phase was unknown to the experts participating in the R2D2P. It also became very clear that the end point of transition depends on the overall decommissioning strategy.

TRAINING COURSES AND WORKSHOPS

A two-week Regional Training Course for Europe on decommissioning of research reactors and other small nuclear facilities was held in Bucharest on 9-20 June 1997. This was the first Training Course or workshop on decommissioning held since 1995. It was followed by a lot of similar events (from one a year in the 1990s to typically three or more a year currently). Initially training events addressed the basic of decommissioning, as it was felt that awareness of decommissioning aspects was of prime interest to Member States. Subsequently, training courses or workshops were specialized in technical areas such as

organization and maintenance, decontamination and dismantling technologies, management of spent fuel, management of decommissioning waste and other materials.
The Bucharest event included participation of 25 trainees from 14 Member States (mostly developing countries) and in addition five Romanians. Attendance of this size is typical in most training events on decommissioning. Simultaneous translation to/from English/Russian was provided. The focus of this course was on Russian-type research reactors (WWRs and IRTs), therefore, a few participants were also selected from non-European countries having Russian-type reactors (Egypt, Libya, Kazakhstan). Six invited speakers, two IAEA Technical Officers and three local lecturers delivered 28 lectures. The course also included a technical visit to the Bucharest reactor under decommissioning and several technical films. Evaluation questionnaires were filled in by participants and assessed by the IAEA.

TECHNICAL ASSISTANCE TO IRAQ

In February 2006 the IAEA initiated a new project on providing technical assistance to Iraq. This activity is mainly directed by IAEA-WES. The objective of the project is to assist the Government of Iraq with the evaluation and decommissioning of the existing facilities that have used radioactive material in the past and were damaged by the Gulf wars. The Agency project has progressed well and continued support is being given by experts from France, Germany, Italy, UK, Ukraine and the USA. Project information and results are available on the Agency's website. A draft nuclear law has been prepared and work on the drafting of regulations covering decommissioning, radiation protection and waste management continues. The primary legislation has passed through the first stage of Iraq's legislative process, and may be expected to be enacted within a year. The project has enabled Iraqi experts to draft policy and strategy documents for the management of radioactive waste, but these have yet to be endorsed by Iraq's regulatory community. Despite the delay in consolidating the regulatory situation, independent scrutiny and challenge is occurring and work is due to start on decommissioning one of the lightly contaminated sites in line with the prioritization of decommissioning activities agreed in 2007. Support for this decommissioning was provided to Iraq via a practical training programme conducted at Pripyat, Ukraine, during June 2008.

THE INTERNATIONAL DECOMMISSIONING NETWORK (IDN)

The International Decommissioning Network (IDN) is viewed by the IAEA as a culmination of previous technical assistance efforts. As a matter of fact, a vision, objectives and Terms of Reference (ToR) for the IDN were evolved incorporating the experience noted above. The objectives of the IDN are to:

- Complement existing IAEA activities with more demonstration projects giving practical hands-on and user-oriented experience.
- Facilitate sharing of experience.
- Raise awareness of need and encourage decision-makers to build a funding framework.
- Attract additional resources to the field and accelerate the pace of decommissioning activities worldwide.
- Act as a "Network of Networks" to increase visibility and leverage learning from national and regional projects & existing networks.

The last bullet is worth a special mention. The IDN does not intend to replace or add many more activities to the TC projects, workshops and other traditional mechanisms described in previous sections. Rather it intends to streamline, coordinate and render those activities more systematic and open to the whole decommissioning community worldwide.

The IDN was launched at a side event at the General Conference in September 2007 with over 40 delegates attending. The IDN brings together those with relevant decommissioning knowledge and experience and those who need to apply it, and provide a means to build and sustain relationships through the sharing of knowledge. Following this successful launch, experts from 35 countries gathered at a Technical Meeting (TM) in Vienna at the end of October 2007 to confirm their intention to participate, adopt the Terms of Reference, define priorities and develop the initial work programme for the Network. The participants indicated their preferences for additional training events and hands-on demonstrations focused on decommissioning of research reactors, fuel-cycle facilities, and other small facilities such as medical or research labs. Drawing on the input received at the meeting, a consultants group met during and after the meeting to outline the most important course areas identified. These included:

- facility (radiological) characterization
- cutting and decontamination techniques
- management and clearance of decommissioning waste
- "general training" on decommissioning to enable managers to develop decommissioning strategies and plans based on appropriate technologies
- cost estimation for small facilities

Since the first programme meeting, efforts have been focused on initiating the new activities recommended by participants in the IDN programme meeting and aligning these activities with ongoing decommissioning work in the IAEA. The European Regional Technical Cooperation Project RER/3/005 "Support in Planning the Decommissioning of Nuclear Power Plants and Research Reactors" noted in Sec. 3 has been one of the most successful of these efforts. Similarly, the experience with "back to back" workshops hosted in the Framework of the R2D2 Project by ANSTO on "Transition to Decommissioning" (Sec 4) and PNRI in Manila on "Characterization Surveys" respectively improved the IAEA's decommissioning team's knowledge of what is needed to move decommissioning beyond the planning stage, along with an understanding of the required IDN "modus operandi": to create events that transfer practical "know-how" from those with relevant decommissioning experience to those with a demonstrated need.

The planning for the top-priority events requested at the TM is progressing. The IDN's "inaugural" event - a workshop offered "cost-free" to the IAEA by ENRESA, Spain, was on Waste Management and Clearance (Oct 2008). Although designed with participants from the European Regional Project on Decommissioning, RER 3005 in mind, participants who are actively involved in the work from around the world requested to take part. The one-week workshop took place starting at the mothballed Vandellos NPP near Barcelona, and continued for the final two days at the ongoing Pimic Project near Madrid, offering a unique opportunity for hands-on experience.

Following this, a workshop (Group Scientific Visit) on Size Reduction for Decommissioning of Nuclear Facilities occurred in Mol, Belgium, and was also hosted "cost free" to the IAEA by CEN/SCK. Designed initially based on the needs and interests of the RER/3/005 participants, this event will feature visual demonstrations and participatory activities to show the decontamination and cutting methods employed at the lab. As for the above workshop, several qualified non-RER participants have asked to participate.
In addition to these activities, continuous improvements to the website are being incorporated, and organization of "web-based" events is evolving: for example, work to restore and transfer some classic decommissioning training videos to DVD and to make the most interesting segments of them available on-line. Based on the interest these generate, teleconferences with experts in the subject areas are being organized.

Planning for IDN events includes workshops on concrete cutting (the MOATA reactor at ANSTO will be dismantled in 2009), and laser cutting technology. Improved access to basic training consistent with IAEA standards is under discussion with the organizations in the US and Europe that currently offer this training. Information on such events is posted on the web-site as it becomes available [7]. In general, the plan for future IDN activities aims to balance activities based on interests expressed by the participants. In particular, an emphasis is placed on "Hands on" training and demos, with the highest interest in decommissioning of smaller facilities such as research reactors and fuel cycle facilities as well as other smaller facilities such as medical or research labs. It is also expected that the IDN will focus on regions where the greatest interest has been expressed (Europe & Asia.), with "seed" activities being carried out in Africa and South America.

RECENT DEVELOPMENTS

Over time, the IAEA has re-oriented its decommissioning programme towards the needs of developing Member States, focusing in particular on research reactors and other small facilities. This includes (i) the demonstration and know-how transfer of simple, dedicated technologies (ii) development programmes tailored to developing Member States and (iii) implementing a larger number of TC projects and Training Courses in a systematic and streamlined fashion. This is necessary as there is a growing number of ageing reactors which are potential candidates to short term decommissioning. In addition, many countries have not paid enough attention yet to planning for decommissioning or to ensuring the needed resources and infrastructure (waste management options, expertise, funds). The IAEA will continue its role of international forum for dissemination of information, guidance and transfer of technologies and know-how. Assistance will be more and more coordinated on the global scale and focused on practical, hands-on applications. Integration with other international organizations active in nuclear decommissioning, such as OECD Nuclear Energy Agency and the European Commission, will be an important indicator of success.

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