Chairperson's Summary, International Expert Meeting on Decommissioning and Remediation after a Nuclear Accident

BACKGROUND

History has clearly demonstrated, and it has repeated itself in the events and aftermath of March 2011, that a major nuclear accident, just as any other major accident, not only affects public and environmental health, but in addition causes a wide range of direct and indirect effects. These include evacuation and relocation; social unrest; indirect health effects related to anxiety, radiological stigma and symptoms of a post-traumatic nature; as well as effects on property, the economy, public policy and politics. All of these factors influence the setting of targets for decommissioning and remediation; this is often an iterative process involving consideration of the legal framework, finances, processes and methodology and technology. Importantly, decommissioning and remediation is carried out in close interaction with stakeholders, of which the public (affected by both the accident and the recovery from its consequences) form an important part.

Today, we have substantial knowledge about the impact of major nuclear accidents as well as a wealth of experience – good and sometimes less so – from a range of decommissioning and remediation projects following nuclear accidents. There are also a number of lessons to be learned from decommissioning and remediation of other legacy sites that have not originated from nuclear accidents but where the problems encountered are of similar nature. Experiences have over the years been discussed in many fora, including a number of IAEA initiatives and UNSCEAR reviews of scientific information on health and environmental effects of accidents and legacies of comparable nature.

It is timely to discuss this knowledge in relation to the Fukushima Daiichi accident, to provide guidance to future actions aimed at strengthening our understanding of the exposure situation, and our ability to successfully carry out decommissioning of facilities and environmental remediation after a nuclear accident.

This International Expert Meeting

This is the fourth in a series of IEMs that have been organised under the IAEA Action Plan on Nuclear Safety. The preceding three meetings dealt with the subjects of Reactor and Spent Fuel Safety; Enhancing Transparency and Communication Effectiveness; and, Protection against Extreme Earthquakes and Tsunamis, all of them in the light of, and building on the experience from, the accident at the Fukushima Daiichi Nuclear Power Plant. This week, approximately 200 experts from close to 40 countries plus several international organisations, had the opportunity to discuss a variety of issues related to decommissioning and remediation after a nuclear accident, again taking stock of experiences from the accident at the Fukushima Daiichi Nuclear Power Plant.

The IEM responds directly to the International Action Plan on Nuclear Safety, which under the umbrella of **protection of people and the environment from ionising radiation**, calls for actions to **ensure the on-going protection of people and the environment from ionizing radiation following an emergency.** For further actions relevant to this and other action items, please consult the Action Plan Dashboard available at the Agency's website.

The meeting held eight separate sessions, covering the following subject matters:

- Decommissioning, environmental remediation and associated waste management challenges resulting from nuclear and radiological accidents.
- Review of experience and strategic lessons learned from past accidents and legacy situations.
- Challenges in decommissioning and remediation.
- Management of radioactive waste and damaged fuel
- Decommissioning standards and technologies
- Improving national and international cooperation for managing the post-accident phase of nuclear and radiological accidents

As for previous IEMs, the Agency will publish a report with presentational material on an accompanying CD ROM. The report will incorporate the session chairs' review of the matter discussed within the different subject matter. In this Chairperson's Summary, I make some general observations and remarks in relation to cross-cutting issues and suggest how they can be captured in recommendations for future work. This Summary will also form part of the final Report.

THE CRUCIAL ROLE OF PLANNING FOR POST-ACCIDENT SITUATIONS

Planning of any activity requires consideration of potential accidents; the activities should be planned so that such accidents do not occur, and if they occur planning should aim at containment of radioactivity, and for mitigating the consequences should any radioactivity be released in any form. This is recognised in the Fundamental Safety Principles [IAEA, 2006] which (Principle 8) states: *All practical efforts must be made to prevent and mitigate nuclear or radiation accidents.*

Radiation protection considers three exposure situations, namely; *planned exposure situations*, *emergency exposure situations*; *existing exposure situation*s, as laid out in the 2007 Recommendations of the International Commission on Radiological Protection, ICRP [ICRP, 2007] and the IAEA Basic Safety Standards (BSS). One of the main purposes of *planning* is to prevent the exposure situation from turning into an emergency exposure situation and/or existing exposure situation. Nevertheless, such transitions occur. Accidents happen and are mostly related to human factors such as incomplete information or knowledge, difficulties in interpreting information, lack of implementation of procedures, negligence or deliberate override of operational limits. Additionally, operations may be carried out, or have been carried out, with limited prior consideration of future need for decommissioning and remediation, or within accepted safety limits but still resulting in onsite and/or offsite contamination that need to be addressed in decommissioning and environmental remediation.

There is no reason to believe that accidents will not happen in the future, leading to future actions related to recovery activities such as decommissioning and remediation. *Before* an accident, planning should identify and establish appropriate procedures to handle acute consequences and bring the situations under control in a manner that reduces, to the extent practicable and possible, the long term consequences that will turn into *legacy*. If such a legacy eventuates, or already exist, a system to deal with it, which includes decommissioning and remediation, must be available.

The discussions held at the IEM highlighted the importance of forward planning and that international guidance can be strengthened in this regard. The meeting discussed the feasibility of generic 'protocols' that would guide post-accident recovery work. Particularly with regard to remediation, a recommendation can be formulated as follows:

> *The IAEA should strengthen its programme on remediation after a nuclear accident to assist Member States to facilitate the return of affected areas to normal conditions.*

The definition of what is "normal" may vary, and requires due consideration of a number of factors, which include, but are not limited to:

- Division of responsibilities including the role of government, the regulatory framework, and financial provisions.
- Approaches to involving stakeholders
- Approaches to defining targets and end states
- Methods and technology
- Development of a generic fuel and waste management program, including classification of waste, predisposal management and conditioning, storage and disposal.

These factors are briefly discussed below.

1. Division of responsibilities – a national framework

The acute phase of a nuclear accident involves the interaction of numerous organisations, with the onsite and offsite rescue service, and local and central authorities playing a major role. Normally, this interaction is frequently exercised – but rarely at the scale required to administer very large and catastrophic accidents, or the combined effects of a nuclear accident with a large-scale natural event such as the Great East-Japan Earthquake and Tsunami in 2011. This may potentially lead to actions that inadvertently cause future problems in the recovery phase, e.g. for decommissioning and remediation. There may be a need to look into specific aspects of the acute management of large-scale accidents from this perspective; however, this was not strictly within the scope of this IEM.

However, analysis and discussion of past events have revealed that, also in the recovery phase, the division of responsibilities between different parties, and the framework for operation, has been unclear, to the detriment of efficiency and effectiveness of actions taken in the recovery phase. Even small such shortcomings may lead to insufficiently informed decisions, taken too late and in worst cases (although in reality probably rarely) counterproductive to the achievement of protection goals. It is therefore essential that there are not any ambiguities in the division of responsibilities between the parties engaged in the recovery.

For the really large accident with major and long-term consequences, the government has a central responsibility; the necessary actions may be beyond the resources (financial and others) of the operators or any other organisation, irrespective of financial arrangements such as insurances. The IAEA Safety Standards, e.g. the Safety Requirements on Governmental, Legal and Regulatory Framework for Safety (GSR Part 1) [IAEA, 2010], provides an outline of an overarching structure.

2. Interaction with stakeholders

The role of stakeholder interaction that is built on identification of roles, transparency, trust and respect, and that supports the achievement of the best outcome under the existing circumstances, is widely acknowledged but it should also be recognised that stakeholder interaction is not a substitute for the need for decision makers to take responsible actions when necessary, either this is government, local municipalities, operators, or any other body with such responsibilities. Thus, the *roles* of different parties involved in a stakeholder interaction need to be clearly defined.

The importance of trust for a constructive stakeholder interaction cannot be overestimated. Trust will not be achieved if potential events (such as accidents) have not been identified and clearly communicated in the planning phase – and it subsequently turns out that such an event takes place.

Other issues are:

- Timing of interaction – stakeholder interaction should be prominent in the pre-accident establishment of response mechanisms at the time when an activity is planned ("those that are affected by policy should have a say in its coming about"), and in defining generic targets for decommissioning and remediation. In the acute phase following an accident there is little if any room for interaction; however, in the transition to an existing exposure situation and later when decommissioning and remediation are planned and implemented, it becomes prominent. Success will be limited, or projects will be seriously delayed, discontinue, or undergo unnecessary reorientation, and will not create an outcome that can be largely embraced by the population, if the stakeholder interaction is not carried out correctly.
- Sustainability of interaction. Anyone who engages with stakeholders in decommissioning and remediation projects has to be prepared to be in it for the long haul. Projects last years to decades, and may approach a century. A strong presence, consistency, transparency and a clear message contribute to trust, which will be built with time if carried out well.

A number of remediation projects were discussed, where the successful outcome had been supported by a constructive stakeholder interaction. Such examples provide valuable experience to be implemented in future projects.

3. Setting objectives and targets for remediation

A very important element of this IEM was the discussions that were held in a number of sessions and that, in one way or another, related to the objectives and targets (and end states) of decommissioning and remediation. Remediation is, if used in a narrow sense, about reducing exposures, through actions directed at the source and/or through actions directed at the exposure pathway – which in extreme cases leads to evacuation. Targets for dose reduction can formulated,

and expressed as *dose* targets, using agreed reference levels as guidance. Targets can also be defined for decommissioning, for example in terms of desired end state.

The ICRP and the IAEA Basic Safety Standards (BSS) recommends that a reference level to guide optimisation in an existing exposure situation should be selected within a range of annual doses of 1 to 20 mSv to members of the public, and can be adjusted as necessary during the course of remediation. The discussions revealed that reference levels or dose reduction targets were generally set within this range, not higher than 5 mSv and in most cases at 1 mSv, i.e. aligned with the annual dose limit for exposure of the public from all man-made sources in a planned exposure situation. These are almost exclusively calculated doses based on certain cautiously conservative assumptions. At least in the case of the Chernobyl accident, direct monitoring shows that actual exposures were usually well below such calculated doses.

Consideration of radiation exposure is indispensible as it provides scientifically based and, in a sense, objective benchmarks against which progress can be assessed. However, the meaning of them may not be easily communicated to the public and a particular problem is the inconsistency in other 'numbers', e.g , activity restrictions on drinking water, foodstuff and commodities, that are designed to assist in keeping within dose targets. There is a strong message from the IEM that a lesson learned from Fukushima is that these numbers should be reviewed to provide a consistent message. The IAEA would be well placed to lead this work, in collaboration with other bodies, e.g. FAO and WHO.

The objective of remediation may be expressed differently depending on who is asked, and this is an area where the interaction with stakeholders is of particular significance. The notion of 'health' needs to be broadened to include other than direct effects of radiation, noting that health is not defined as the absence of a disease but, by WHO, as a state of *physical, mental and social well-being*. Experts may deal with doses and risks, and health issues, in an objective fashion but also experts would tell their children not to eat the ice cream they have dropped on the floor, not because the risk associated with eating it has been assessed but because of a vague notion of it being "dirty". Such non-quantifiable issues are close to the human nature and closer to the heart; the questions that needs to answered are "can I drink this water?", "can my children go to school here?" and "can I eat my home-grown vegetables?". The objective of remediation, when discussed in this way, is the resettlement of people and return to normal life and livelihood.

For a community, the objective may be described as follows, which is based on the recovery goals of the Fukushima Prefecture:

- To guarantee the safety and security of residents
- To regenerate and revitalise primary industry
- To become a hub of leading industries
- To promote the use of local resources and skills in e.g. tourism and crafts

It was repeatedly pointed out that accidents are unique with their own set of characteristics. Remediation may in some instances be complicated further by the fact that some accidents may occur against a backdrop of already high levels of discharges and offsite impact. Also, some accidents are not purely radiological; they may be combined with spread of hazardous chemicals, or, as in the case of Fukushima, the consequences of the nuclear accident occurs on top of the far-ranging

devastation caused by an earthquake and tsunami. The challenge is to reach a balance between different actions addressing various consequences of such combined accidents, in order to achieve optimized health and environmental protection.

Thus the formulation of objectives and targets is a complex process, based on fundamental concepts of radiation protection and understanding of radiation risks, understanding of health issues in general, and iterations with stakeholders to achieve the optimal outcome under the local circumstances. The formulation and agreement on objectives would be facilitated by improved ability to communicate 'what is safe'. A recommendation for future work can be formulated as follows:

> *The accident at the Fukushima Daiichi Nuclear Power Plant has highlighted the concern of people to be assured of their safety. The international community should strive to develop a practical definition of 'safe' as an aid for communicating with the public.*

4. Methods and technology

The IEM provided participants with an update on methodologies and technology. A number of presentations were made by Japanese colleagues, providing participants with very clear examples of important issues to address in terms of methodologies and techniques, the approach to resolving the issues and the successful implementation. The importance of relying on proven technology and innovative use was emphasised. Furthermore, it was noted that decommissioning and remediation has developed into an 'industry' which generates innovations to satisfy the needs of the customers for cost-effective methodologies and techniques. Participants from industry provided very useful information from this rapidly evolving field.

It is noteworthy that that the 'customers' – in a broad sense – are not only corporations or governments. Web-based tools to assist the public, e.g. house-owners, have been developed and made accessible.

The IAEA could have a role in keeping a record of the available methodologies and techniques, to facilitate their implementation globally, which includes countries with insufficient infrastructure to support the necessary technology, but where the legitimate use of radiation may have caused legacies that need to be addressed and remediated. Furthermore, the IAEA may consider the feasibility of dispatching a team of international experts providing early advice on the preparations for the long term recovery actions.

5. Management of damaged fuel and radioactive waste

Examples discussed during the IEM pointed to the very significant problems encountered when dealing with the damaged fuel and radioactive waste generated by an accident, and subsequent decommissioning and remediation. Problems are encountered in both the high-activity and low-activity end of the spectrum:

- Damaged fuel poses particular problems as it retains its basic radiological hazard whereas the matrix has been damaged to an extent that makes it unsuitable for conventional management.

- Large volumes of very low level waste may be generated during remediation, where the volume of the waste presents a challenge for its management.

The sequence and timing of defueling and removal of damaged fuel are important to consider when planning for the decommissioning of accident damaged reactors since, for example, the properties of the damaged fuel change over time.

While these problems would not be encountered in normal operation, they can be foreseen as a result of an accident and should thus be addressed in the planning stage. This can be accomplished by the development of generic methods captured by 'generic safety cases and supporting safety assessments', which cover the categorisation, conditioning, storage and ultimate disposal of the waste, as well as criteria for clearance. The safety case(s) need to address the peculiarities of waste generated from an accident and need to give consideration to the end state of decommissioning.

With regard to waste management strategies, a recommendation can be suggested as follow:

> *The Agency should assist Member States with the development of end states and decommissioning strategies for decommissioning of accident damaged facilities..*

With particular reference to the large volumes of – often – low activity waste from existing exposure situations, a recommendation can be suggested as follows:

> *Large volumes of radioactive waste and materials with residual amounts of radionuclides are present in many countries. The Agency should review its guidance on the management of these wastes and materials with the view of ensuring their practical application after a nuclear accident. .*

CONCLUDING REMARKS

Whilst the knowledge base for decommissioning and remediation activities is sound, the IEM identified aspects where there is room for improvement. It is important that these issues are addressed by the nuclear safety and radiation protection community, either this is achieved through amendments of instruments such as conventions, new instruments, IAEA General Conference Resolutions, improved guidance, improved sharing of knowledge and experience, strengthened review services for planning of remediation, or any other action or a combination thereof. The Agency has a vital role in driving this process under the terms of the Action Plan on Nuclear Safety.

Detailed conclusions regarding status and future work in specific areas will be included in the final report. As for this summary, the following suggested recommendations for future Agency activities and broadly related to Action Item 10 of the Action Plan, have been identified:

1. *The IAEA should strengthen its programme on remediation after a nuclear accident to assist Member States to facilitate the return of affected areas to normal conditions.*
2. *The accident at the Fukushima Daiichi Nuclear Power Plant has highlighted the concern of people to be assured of their safety. The international community should strive to develop a practical definition of 'safe' as an aid for communicating with the public.*
3. *The Agency should assist Member States with the development of end states and decommissioning strategies for decommissioning of accident damaged facilities.*

4. *Large volumes of radioactive waste and materials with residual amounts of radionuclides are present in many countries. The Agency should review its guidance on the management of these wastes and materials with the view of ensuring their practical application after a nuclear accident.*

The participants and contributors to the discussions are thanked for making their thoughts and expertise available to all, and for their engagement and constructiveness in the discussions.

Carl-Magnus Larsson

IEM Chairperson