Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 25-26, 2012

Technological factors influencing selection of strategies for decommissioning of nuclear facilities

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1. Introduction

A number of factors must be weighed and balanced when preparing the decommissioning plan for a nuclear power plant. The plan will vary with each facility and these factors must be evaluated on a case-by-case basis. The factors to be considered when selecting the optimum strategy for the decommissioning of the nuclear facility include the national nuclear policy, the characteristics of the facility, health and safety, environmental protection, radioactive waste management, future use of the site, improvements of the decommissioning technology that may be achieved in the future, costs and availability of funds for the project and various social considerations [1, 2]. In this paper, technological aspects of lots of factor affecting decommissioning were considered.

2. Technological factors

2.1Radiological Aspects

The continuation of effective public and occupational radiological protection is a primary consideration in the process of strategy selection. In this regard, there is potential for taking advantage of the natural decay of radionuclides over time, and the consequent reduction of radionuclide inventory and dose-rate. By waiting for sufficient radioactive decay, decommissioning operations may be carried out safely without resort to remote handling equipment, robotic devices, etc, and volumes of radioactive waste may be reduced. However, this advantage applies only to situations where the main radionuclides are short-lived, such as ^{60}Co, which has a half-life of about 5 years. On the other hand, in the case of actinides, it has to be taken into account that deferral may be detrimental from a radiological point of view because of an in-growth of Am-241 from the decay of Pu-241.

As regards reduction in waste volumes, the benefit of radioactive decay lies primarily in the possibility of reducing the radionuclide inventory of large volumes of material to levels that will allow it to be cleared for reuse, recycle or disposal as conventional waste. Clearly, the extent of this benefit depends on national clearance levels and on the availability of routes for reuse or recycling.

2.2 Availability of Technology for Decommissioning

These techniques are already well developed and proven in practice. Indeed many of the dismantling techniques are based on conventional equipment adapted as necessary for nuclear application. Most operations can now be carried out remotely and safely, without excessive cost. In this context, the main strategic question is about the extent of further research and development that may be helpful in further reducing costs and dose commitment and enhancing efficiency and safety of the operation. It would also be helpful to develop or seek approval for techniques of transporting and disposing of large items of plant and equipment, as this would reduce the requirement for cutting, at least. Also in this strategic context, countries with small nuclear programs or with only a research reactor, perhaps, will need to consider how far to go in developing a local capability in applying these techniques, as opposed to depending upon contracted effort from elsewhere.

Some of the systems and components already installed on a nuclear facility, such as ventilation systems, lifting and moving equipment, could be used for decommissioning operations provided it has been maintained in good order, with current safety certification. This qualification may be difficult to satisfy if dismantling is deferred for a lengthy period of time, during which such systems and components are likely to deteriorate and their safety certification to expire. In such an event, their re-commissioning might be impracticable and they might have to be replaced at significant cost. The same point applies to structures; both in the case of simply assuring continued safety of the facility as well as in the case of any temporary reuse.

2.3 Physical and Radiological State of Facilities

One of the first steps after shut down of any nuclear facility is the so-called "post operational clean out". Amongst other things, this involves flushing of pipe work and vessels to remove as much contamination as possible. The residual physical and radiological state of a facility will then influence the strategy for decommissioning it, particularly if it remains highly contaminated or if its physical structure is in a poor state and likely to deteriorate. In such a situation early action might be necessary for securing its safety. Hence both physical and radiological characterizations are essential inputs.

Physical characterization normally involves inspection of the facility in order to detect hazards and identify the arrangements required for protection against any abnormal conditions.

Radiological characterization has two main purposes. The first involves identification of the radiological hazards to workers who will have to enter the facility in order to carry out decommissioning tasks. This identification of hazards helps to determine whether or not it is necessary to decontaminate any areas of the plant for direct worker access, and it facilitates the design of radiological protection measures for later activities. This work includes the sampling of unknown materials, the updating of radiological maps and the estimating of physical parameters and quantities of waste arising from later decontamination and dismantling tasks.

The second purpose is to establish, at a more detailed level, the inventory of radionuclides in materials that will require storage, disposal as radioactive waste or release from regulatory control by way of clearance arrangements. This work also continues as decommissioning progresses and as access becomes available. For technical reasons associated with ease of detection and measurement, the work is most conveniently done by detecting and measuring γ-emitting radionuclides such as ^{60}Co and ^{137}Cs and calculating the quantities of other radionuclides by way of known correlations with the measured species. However, the easy-to-measure radionuclides have relatively short half-lives, (5 years for ^{60}Co and 30 years for ^{137}Cs) so this element of the task becomes more difficult and complex the longer dismantling is deferred.

3. Conclusions

Strategy selection is an important element in the safe decommissioning of nuclear facilities. It depends on a large number of factors that have to be taken into account when decisions on immediate dismantling, deferred dismantling/safe enclosure or entombment are to be made. In general, entombment is not a recommended decommissioning option. It may, for example, be selected in a country with a single nuclear power plant. In general, strategy selection is a choice between immediate and deferred dismantling.

At present, the emerging international trend is immediate dismantling. The societal concerns about the consequences of deferred dismantling seem to be a significant factor, at government level at least. The input of stakeholders/communities into the decision-making process varies among countries.

The uncertainties about conservation of knowledge and expertise, evolution of costs/funding, liabilities, and waste management are also very important. The influence of radioactive decay seems applicable to only certain types of facilities, and is often outweighed by other factors, e.g. eventual cost savings/worker doses are offset by those accrued during safe enclosure. Remote handling technology is available and has been applied in several instances. The costs of remote handling technology have also not been an issue. These two facts reduce pressure for delay for decay.

Costs and cost minimization are of very high importance to the operators of nuclear facilities, but also to the regulators because they must ensure that funds will be available when needed. Precise cost calculations, the accumulation of sufficient funds during operation and the security of funds, in particular if dismantling will be deferred, are of vital importance. Underlying all of this, minimization of costs is still an influencing factor, e.g. in phasing decommissioning of multiple facilities on the same site.

The degree of certainty about the desired end-state may influence the choice of immediate or deferred dismantling. Where future nuclear policy is clear, whether for continued development or phasing out, there would be no risk in selecting immediate dismantling. Where the policy is not clear, and where the desired end-state is unclear, and/or a repository is not available, there may be a tendency to select deferral until the requirements for the site are clear or a repository is available.

This large number of influencing factors and the extremely large variety of these factors makes it easily understandable that decisions regarding strategy selection can be different in different countries for a similar facility or in one country for different sites.

REFERENCES

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[2] OECD/NEA, Selection of Strategies for Decommissioning of Nuclear Facilities, 2006.