Environmental and ethical aspects of long-lived radioactive waste disposal

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NUCLEAR ENERGY AGENCY
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Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

— to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
— to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
— to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

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The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of the OEEC European Nuclear Energy Agency. It received its present designation on 20th April 1972, when Japan became its first non-European full Member. NEA membership today consists of all European Member countries of OECD as well as Australia, Canada, Japan, Republic of Korea, Mexico and the United States. The Commission of the European Communities takes part in the work of the Agency.

The primary objective of NEA is to promote co-operation among the governments of its participating countries in furthering the development of nuclear power as a safe, environmentally acceptable and economic energy source.

This is achieved by:

— encouraging harmonization of national regulatory policies and practices, with particular reference to the safety of nuclear installations, protection of man against ionising radiation and preservation of the environment, radioactive waste management, and nuclear third party liability and insurance;
— assessing the contribution of nuclear power to the overall energy supply by keeping under review the technical and economic aspects of nuclear power growth and forecasting demand and supply for the different phases of the nuclear fuel cycle;
— developing exchanges of scientific and technical information particularly through participation in common services;
— setting up international research and development programmes and joint undertakings.

In these and related tasks, NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has concluded a Co-operation Agreement, as well as with other international organisations in the nuclear field.

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Foreword

All countries engaged in nuclear production give particular attention to the safe disposal of radioactive waste, particularly as regards the need to protect humans and the environment in the distant future. Many other countries making use of radioactive materials for medical, industrial or research purposes only are also concerned by this issue. Practically speaking all countries are generally interested in keeping abreast of the development of radioactive waste management policies and of underlying technical and non-technical studies.

The NEA Radioactive Waste Management Committee (RWMC) has been instrumental, since the late 70s, in organising periodic reviews of national policies and scientific developments focusing on the practical solution offered by deep geological repositories for the long-term isolation of radioactive waste from the biosphere. However, in spite of their importance for the assessment of long-term safety, scientific and technical studies are only one part of the current debate on radioactive waste management. Broader issues, such as environmental protection in general, ethical aspects, public perception and decision-making, become increasingly important at a time when radioactive waste disposal programmes start to be implemented at national level. Accordingly, the RWMC decided in 1994 to organise a workshop to stimulate an exchange of views on these questions and to provide a broad basis for an in-depth reflection on long-term waste disposal issues, particularly the non-technical questions which may not have been sufficiently discussed and explained.

The workshop was organised in Paris, on 1st-2nd September 1994, in co-operation with the OECD Environment Directorate. The focus was the concept of deep geological disposal and the associated non-technical long-term issues. Invited specialists in environmental protection and ethics addressed these issues and took part in an exchange of views with members of the RWMC.

These proceedings reproduce the papers by the invited speakers, and the full workshop discussions. The opinions presented are those of the speakers only and do not necessarily express the views of any Member country or international organisation. These proceedings are published on the responsibility of the Secretary-General of the OECD.
ORGANISATION DE COOPÉRATION ET DE DÉVELOPPEMENT ÉCONOMIQUES

En vertu de l'article 1° de la Convention signée le 14 décembre 1960, à Paris, et entrée en vigueur le 30 septembre 1961, l’Organisation de Coopération et de Développement Économiques (OCDE) a pour objectif de promouvoir des politiques visant :

— à réaliser la plus forte expansion de l’économie et de l’emploi et une progression du niveau de vie dans les pays Membres, tout en maintenant la stabilité financière, et à contribuer ainsi au développement de l’économie mondiale ;
— à contribuer à une saine expansion économique dans les pays Membres, ainsi que les pays non membres, en voie de développement économique ;
— à contribuer à l’expansion du commerce mondial sur une base multilatérale et non discriminatoire conformément aux obligations internationales.


L’AGENCE DE L’OCDE POUR L’ÉNERGIE NUCLÉAIRE

L’Agence de l’OCDE pour l’Énergie Nucléaire (AEN) a été créée le 1er février 1958 sous le nom d’Agence Européenne pour l’Énergie Nucléaire de l’OCDE. Elle a pris sa dénomination actuelle le 20 avril 1972, lorsque le Japon est devenu son premier pays Membre de plein exercice non européen. L’Agence groupe aujourd’hui tous les pays Membres européens de l’OCDE, ainsi que l’Australie, le Canada, la République de Corée, les États-Unis, le Japon et le Mexique. La Commission des Communautés européennes participe à ses travaux.

L’AEN a pour principal objectif de promouvoir la coopération entre les gouvernements de ses pays participants pour le développement de l’énergie nucléaire en tant que source d’énergie sûre, acceptable du point de vue de l’environnement, et économique.

Pour atteindre cet objectif, l’AEN :

— encourage l’harmonisation des politiques et pratiques réglementaires notamment en ce qui concerne la sûreté des installations nucléaires, la protection de l’homme contre les rayonnements ionisants et la préservation de l’environnement, la gestion des déchets radioactifs, ainsi que la responsabilité civile et l’assurance en matière nucléaire ;
— évalue la contribution de l’électronucléaire aux approvisionnements en énergie, en examinant régulièrement les aspects économiques et techniques de la croissance de l’énergie nucléaire et en établissant des prévisions concernant l’offre et la demande de services pour les différentes phases du cycle du combustible nucléaire ;
— développe les échanges d’information scientifiques et techniques notamment par l’intermédiaire de services communs ;
— met sur pied des programmes internationaux de recherche et développement, et des entreprises communes.

Pour ces activités, ainsi que pour d’autres travaux connexes, l’AEN collabore étroitement avec l’Agence Internationale de l’Énergie Atomique de Vienne, avec laquelle elle a conclu un Accord de coopération, ainsi qu’avec d’autres organisations internationales opérant dans le domaine nucléaire.

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Avant-propos

Dans tous les pays dotés d'un parc électronucléaire, l'évacuation des déchets radioactifs dans des conditions de sûreté fait l'objet d'une attention particulière, compte tenu de la nécessité d'assurer une protection de l'homme et de l'environnement dans un avenir lointain. Il en est de même dans la plupart des autres pays où les matières radioactives ne sont utilisées qu'à des fins médicales et industrielles ou dans la recherche. En pratique, tous les pays s'intéressent à la mise au point des politiques de gestion des déchets radioactifs ainsi qu'aux études techniques et non techniques qui y sont liées.

Depuis la fin des années 70, le Comité de la Gestion des Déchets Radioactifs (RWMC) a procédé à des examens périodiques des politiques nationales et des développements scientifiques, en mettant l'accent sur la solution pratique offerte par les dépôts géologiques profonds pour l'isolement à long terme des déchets radioactifs de la biosphère. Cependant, malgré leur importance du point de vue de l'évaluation de la sûreté à long terme, les études scientifiques et techniques ne constituent que l'un des éléments du débat actuel sur la gestion des déchets radioactifs. La prise en compte de questions plus larges, telles que la protection de l'environnement en général, les aspects éthiques, la perception du public et les procédures de prise de décision, revêt une importance croissante au moment où la mise en œuvre des programmes d'évacuation de déchets radioactifs est entreprise au plan national. En conséquence, le RWMC a décidé, en 1994, d'organiser une réunion de travail pour stimuler un échange de vues sur ces questions et fournir une base plus large à une réflexion approfondie sur les aspects à long terme de l'évacuation des déchets, notamment sur les questions non techniques qui n'ont peut-être pas été suffisamment examinées et expliquées.

Une réunion de travail a été organisée à Paris, les 1 et 2 septembre 1994, en coopération avec la Direction de l'Environnement de l'OCDE. L'accent portait sur le concept d'évacuation en formations géologiques et les questions non techniques à long terme. Des spécialistes de la protection de l'environnement et de l'éthique ont été invités à débattre de ce sujet et ont participé à un échange de vues avec les membres du RWMC.

Le présent compte rendu contient les exposés présentés par les orateurs invités, ainsi que l'intégralité des discussions de la réunion de travail. Les opinions qui y figurent sont celles des orateurs et n'expriment pas nécessairement les points de vue des pays Membres ou des organisations internationales. Le compte rendu est publié sous la responsabilité du Secrétaire général de l'OCDE.
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INTRODUCTORY SESSION
Welcoming Address

Kunihiko UEMATSU
Director General of NEA

I am happy to welcome you to this workshop on the environmental and ethical aspects of long-lived radioactive waste disposal organised by the NEA Radioactive Waste Management Committee. The NEA has a long tradition in the field of radioactive waste management and this meeting gives me the opportunity to note the considerable evolution that has taken place over the past few decades and the role of the NEA. Our general objective at the NEA is to be at the forefront of the scientific and technical debate in the field of nuclear energy and to provide a forum for discussions of policy-oriented issues of interest to our Member countries.

We started to be active on radiation protection and technical questions related to the management of radioactive waste some thirty years ago with a discussion on effluent releases and treatment, conditioning and storage techniques. However, we have always considered that disposal was a key step to be addressed because interim storage is usually designed as a temporary solution which must necessarily be followed by action to take care of the uncertainties for the future in a responsible and definitive manner. Gradually, therefore, the NEA activities in this field have evolved to cover disposal of solid wastes and this received strong support from the RWMC, the Radioactive Waste Management Committee, set up by the NEA in 1975.

In spite of all the technical efforts at the national and international levels we have to admit that final disposal of radioactive waste continues to be regarded as a significant challenge, particularly with regard to the non-technical aspects which directly affect the future deployment of nuclear energy programmes in most countries. This may be the reason that radioactive waste management is sometimes referred to as technical/political engineering.

Over the last fifteen years or so, the Radioactive Waste Management Committee has placed the emphasis of its programme on long term disposal issues; notably on the concept of geological disposal. Accordingly, safety assessment studies and the characterisation of potential disposal sites are the main pillars of our programmes. These are essentially scientific and technical activities.

The other major aspect of the waste management issue is of a different, but related, nature. This is the political, or let us call it ethical or philosophical, dimension which is becoming increasingly important with the progress being made in science and technology. We know from the Radioactive Waste Management Committee’s most recently published "collective opinion" that geological disposal of long-lived radioactive waste could be made safe provided we select suitable sites which can be properly evaluated. However, given the need to ensure safety over many thousands of years we need to use our scientific and technological expertise to the best of our ability to offer satisfactory answers to the philosophical issues which are unavoidably associated with the long term protection of our descendants and environment. This is where our workshop comes in.

In view of the ongoing debate in many of our Member countries, this workshop does seem to be particularly timely and it may constitute an important step in the resolution of the difficulties faced at the non-technical level in general. Although this resolution may take time, I am relatively optimistic
that more and more people in various sectors and from different perspectives are conscious of the need to discuss these issues objectively and constructively. Nuclear experts are increasingly involved in exchanges concerning the protection of the environment and we ourselves welcome external contributions. I am very pleased in this respect to note that during the preparation of this workshop we have been able to benefit from the strong support of the OECD Environment Directorate and notably from Mr. Long, its director and one of this morning's speakers, together with his colleague, Victor Morgenroth. I am also impressed by the list of speakers who are going to be making presentations on topics which are of considerable interest to us. I would like to thank them all in advance for their assistance.

Before giving the floor to Dr. Ron Flowers, the workshop chairman and previous chairman of the Radioactive Waste Management Committee of the NEA, I would like to invite all of you to a reception tonight. I hope this will facilitate exchanges and help to promote a good understanding of the relevant environmental and philosophical arguments for the continuation of the discussion tomorrow. I wish you success in your deliberations and I look forward to knowing the results. Thank you for your attention.
Introductory Remarks

Ron FLOWERS
Workshop Chairman

Let me welcome you all to this two day workshop on the environmental and ethical aspects of long-lived radioactive waste disposal. This is necessarily a meeting with restricted attendance, so I should explain that we have present at the workshop nominated delegates from NEA Member countries together with a number of invited speakers who are experts in our subject. May I also welcome our interpreters for the workshop. They will make it possible for us to use both French and English throughout the two days.

The Radioactive Waste Management Committee of the NEA in line with the forward policy of the Steering Committee has been working for the past two years towards increased so-called horizontal integration with other standing Committees of the NEA and, also, with other directorates of the OECD. In particular, the pioneering work done by Member countries in the field of safe disposal of long-lived radioactive wastes makes it very appropriate that we should seek mutual assistance in discussions with the Environment Directorate. On that account I should like to especially welcome Bill Long, Director of the Environment Directorate, and Victor Morgenroth of the Environmental, Health and Safety Division of that Directorate to this meeting. We are very pleased indeed to see them here.

The general thought behind this workshop is as follows: there has been a great deal of technical achievement by the nuclear industry and the regulatory and safety authorities in Member countries in the areas of radioactive waste, packaging, storage and disposal. Out of this has come a fair measure of international agreement that deep underground disposal of these wastes under well controlled conditions at well chosen sites will reach high standards of long term safety. In 1991, the RWMC published a collective opinion on long term safety evaluations expressing satisfaction that under such conditions assessments of repository performance can indeed be made over time scales unprecedented in toxic waste management. At the February 1993 meeting, the RWMC agreed that it would be very helpful to policy makers and the public if a complementary collective opinion could be drawn up to explain the ethical and environmental arguments underlying such a waste disposal strategy. This is an area where expertise certainly cannot be presumed to reside only within the nuclear industry, so we decided that a workshop should be held to encourage open debate amongst experts representing the wider field of toxic waste disposal and the more general aspects of ethical behaviour towards future generations. Out of the proceedings of this workshop should come the ideas which will assist the RWMC in drafting the new collective opinion.

I should like to make one point about our handling of the subject of ethical behaviour at this workshop. The English Oxford dictionary offers a definition of what is ethical, namely "morally correct human conduct". It offers a definition of what is moral, namely "concerned with the distinction between right and wrong." It follows that one cannot know what is ethically right without consulting the people at large. In these two days we do not plan to discuss the important subject of the process by which people may be consulted in Member countries. Rather we aim to identify what appears to us, as a set of involved citizens, to be ethically correct strategies for the disposal of toxic wastes existing and produced by modern industry. These views will guide the RWMC in its collective opinion and that
collective opinion can hopefully serve as an input to the various national debates on waste management policy.

The structure of this workshop was considered very carefully by members of the RWMC together with Dr. Victor Morgenroth of the Environment Directorate. We decided on a programme which will focus on three main topics, following an introductory paper by Colin Allan of AECL which will set the radioactive waste management scene. Three sessions focus on current environmental policies this morning; ethics and the environment this afternoon; a review of radioactive waste management strategies tomorrow morning; and then a concluding session lead by Bob Bernero of the US NRC tomorrow afternoon. The input of ideas and opinions in the papers by the invited experts is essential to informed discussion of these subjects. In order to leave proper time for those discussions we have arranged that presentations be made in fifteen to twenty minutes each. I do ask for your cooperation in working with me as your chairman to keep to time so that we can cover the whole programme by 4 P.M. tomorrow. I suggest that in the discussion periods you indicate your wish to speak by standing your country name plate on end. I will then do my best to give you the floor.

The RWMC group decided at an early stage that in order to focus the presented contributions on the ethical and environmental issues which should be addressed in the new collective opinion, a background document should be available to the invited authors. You have copies of our attempt to write such a document and you will see that it does contain sections corresponding to the three main session headings. We should particularly try to address this afternoon the questions posed in section 4 of the background document since they do seem to cover the important ethical issues identified by the group and by, for example, the Swedish, Canadian and Dutch authors of the appendices to that paper.

I hope that together we will be able to develop and express some views on the merits of the geological disposal concept which has been advanced over many years for the disposal of long-lived radioactive wastes, taking note of all those rather non-technical aspects of ethical behaviour and environmental protection which are important to the concepts of intergenerational equity and sustainable development. The NEA will publish the workshop proceedings and I am sure that they will be valuable to the construction of the RWMC collective opinion during 1995. To help this process the whole of this meeting will be recorded so that after you have seen and commented on the draft proceedings the transcript can be published.

I now call on Colin Allan, Vice-Chairman of the RWMC and Vice-President of Atomic Energy of Canada Limited to start our workshop by setting the scene of radioactive waste management strategies as they now stand.
Radioactive Waste Management Strategies: Setting the Scene

C.J. Allan
RWMC Vice-Chairman
AECL Research, Whiteshell Laboratories
Pinawa, Manitoba, Canada

Background

The development of technology and industrial infrastructure has contributed to the high quality of life now enjoyed by modern societies. Since the early part of this century, research and development has been ongoing in the field of nuclear science, leading to a variety of applications of the technology

- in medicine;
- in industry; and
- in electricity generation.

As with all human endeavours these applications lead to the production of waste. The diversity of uses of nuclear technology results in varied forms of waste and a variety of potential hazards, depending on the concentrations and half-lives of radionuclides and the physico-chemical nature of the waste [1].

Waste may occur:

- in gaseous form, such as ventilation exhausts from facilities handling radioactive materials;
- in liquid form, ranging from scintillation liquids from research facilities to highly radioactive liquids from the reprocessing of spent fuel; or
- in solid form, ranging from contaminated trash and glassware from hospitals, medical research facilities and radiopharmaceutical laboratories, to vitrified waste from reprocessing used fuel, or used fuel from nuclear power plants, when it is considered a waste.

The radioactivity in such waste may range from very low levels, as in waste resulting from the use of radiolabels in medical diagnostic procedures, to very high levels, such as waste resulting from reprocessing used fuel, or in spent radiation sources used in radiography, radiotherapy or sterilization. Radioactive waste may be very small in volume, such as a spent sealed radiation source, or very large and diffuse, such as the tailings from mining and milling of uranium ores.

While the generation of radioactive waste should be minimized where economically possible, the waste exists nonetheless, and will continue to be produced in the future. Therefore it must be managed to ensure protection of human health, both now and in the future. The hazards of radioactive waste are known, and consequently it is handled with care. Current radiological protection principles and regulations provide for the careful and safe management of radioactive waste.

As with other waste, there are two main options for managing radioactive waste. The first is to contain and isolate the waste from the environment for as long as is necessary. The second option
is to disperse material in the environment at levels which do not produce an unacceptable radiological risk. In the case of dilution and dispersion, the quantities released to the environment must be controlled, to ensure that human health and the natural environment are protected. While dilution and dispersal have been used to a limited extent, the majority of radioactive waste produced in OECD countries is contained and isolated. Many years of experience have been accumulated with storage systems to contain and isolate such waste. Such systems have clearly demonstrated that they meet the objectives of protecting public and occupational health and the environment.

Systems for the final disposal of wastes that contain predominantly short-lived radionuclides have been licensed and are in operation in a number of countries, e.g., Finland, France, Japan, Spain and Sweden. Once the waste has been emplaced, there is no intent to retrieve the waste for further processing. In developing disposal strategies for wastes that contain predominantly short-lived radionuclides, advantage can be taken of the fact that the hazard from such waste will decay to a level at which there is no residual risk to human health or the environment after a suitable period of time (up to a few hundred years). For short-lived wastes, disposal strategies can include monitoring as an integral component of the strategy since the required monitoring period is relatively short.

Some radioactive materials, particularly used nuclear fuel and the long-lived waste that occurs from reprocessing used fuel, have a much longer half-life and present a hazard for many thousands of years. (For the purpose of this discussion, nuclear fuel waste is defined as either used nuclear fuel, if it is considered a waste and is not reprocessed (as is the case in countries such as Canada, Spain, Sweden and the U.S.A.), or the highly radioactive waste that results from reprocessing used fuel and separating the plutonium and uranium from the fission and other activation products (as is done, for example, by France, Germany, Japan and the U.K.).) The long-term management of such material presents special considerations. The remainder of this paper will focus on nuclear fuel waste, but the discussion is generally applicable to waste containing significant quantities of long-lived radionuclides.

Nuclear fuel waste is presently stored, either in wet storage systems (water-filled pools) or in dry storage systems (concrete or metal structures). While supporting research and development indicates that such storage practices can safely continue for many decades to come, there is a recognition that storage must be considered an interim measure for long-lived waste. Such systems require active institutional controls, such as monitoring and maintenance of the system and the implementation of security measures to ensure safety, e.g., to prevent inadvertent human intrusion. In addition, the nuclear waste management community has long recognized that radioactive waste should be managed in a way that will not impose undue burdens on future generations.

Consideration for future generations is a fundamental concern in the management of radioactive waste. This concern arises from the ethical principle that the generation that produces waste should bear, to the extent possible, the responsibility to manage it [1]. The responsibility of the present generation includes, constructing and operating storage facilities, providing a funding system and sufficient controls for the management of radioactive waste, and developing the means and the technology for disposal. Disposal may be defined as an indefinite and passive solution for the containment and isolation of long-lived radioactive waste from the environment; there would be no requirement for further intervention by humans, nor a requirement for institutional control. In addition, there would be no intention to retrieve the waste or handle it further in the future, although retrieval may be possible.

The timing and implementation of disposal of individual radioactive waste types involves a number of scientific, technical and economic factors, such as the availability and development of suitable sites and the decay of radioactivity and heat during interim storage. Timing and implementation are also affected by political and public acceptance.
Based on the need to ensure long-term safety and an ethical concern for future generations, many countries are developing the technology to dispose of long-lived radioactive waste. The alternatives which have been examined internationally include disposal under the deep seabed, transportation into space and separation and transmutation. Some countries that reprocess fuel (e.g., France and Japan) are investigating ways to treat the waste from reprocessing operations to simplify waste management by developing practical techniques for transmuting the long-lived radionuclides into short-lived species [2]. The potential impacts of separation and transmutation have been reviewed by many agencies. Early studies [3] of partitioning and transmutation (P&T) as a waste management option concluded that while P&T was technically feasible, there were "no cost or safety incentives for P&T of the actinides for waste management purposes." In 1992, Ramsott et al., concluded [4], "P&T is neither an alternative to the current geologic disposal program nor essential to its success . . . There remain no cost or safety incentives to introduce P&T into the HLW (High-Level Waste) Management System." Studies by international agencies are also consistent with this opinion. In 1991, an IAEA Advisory Group concluded that current and proposed P&T programs are long-term projects that could not impact on the present fuel cycle strategy, and that the P&T option "cannot avoid the need for long-term deep geological disposal" [5]. In 1992, the Radioactive Waste Management Committee of the OECD Nuclear Energy Agency re-emphasized that "actinide separation and transmutation should not be considered as an alternative to geological disposal" [6]. Thus, the current perspective is that disposal of nuclear fuel waste and other material contaminated with long-lived radionuclides will be required whether or not used fuel is reprocessed, and whether or not practical techniques can be developed for separating and transmuting the long-lived waste components [7].

There is a broad international consensus among waste management experts that the preferred method of waste management for long-lived radioactive waste is that based on deep geological disposal, utilizing a system of engineered and natural barriers to ensure long-term safety. (The Netherlands is a notable exception and has adopted a position incorporating the principles of reduction, storage and retrievability, rather than disposal.)

Assessments of national programs have been carried out, (e.g., Sweden and Switzerland), as well as reviews of the concept of deep geological disposal by international organizations, and the approach is considered to be feasible in providing a passively safe option for disposal which will not harm either humans or the natural environment. In 1982, the World Health Organization stated [8]:

"The technology required for the safe disposal of radioactive waste is considered to be already available. Although none of the options has yet been used or proven, conservative engineering practices and the use of multibarriers (combinations of man-made or natural barriers between the waste and the environment) may be expected to make up for the lack of knowledge and degree of uncertainty in predicting what may actually be required of a repository."

Currently, the international perspective is that disposal facilities for long-lived waste will not be operational before about 2010-2020. National efforts, for the most part, are concentrated on research and development activities to evaluate the safety and feasibility of various alternatives, the selection of suitable disposal sites and optimization studies covering safety, environmental, industrial and economical issues.

**Objectives for Radioactive Waste Management**

The objectives of radioactive waste management are to manage radioactive waste in a manner that protects worker safety, public health and the environment, now and in the future, and to do so in a manner that minimizes, to the extent possible, the burden placed on future generations.
To meet the objective of minimizing the burden on future generations, one of the goals of deep geological disposal is to develop a facility that will be passively safe, that is, one that does not require institutional controls for long-term safety. This does not mean that society will not choose to exercise institutional control, but it does mean that if institutional control is lost for whatever reason—war, neglect, oversight, or loss of institutional will or memory—that future generations will not be exposed to a health risk or an environmental detriment.

Although there is a wide variety of technical issues that still need to be addressed, there is widespread consensus within the technical community that these issues are tractable.

The Multi-barrier System

The disposal concepts being developed internationally for deep geological disposal are based on a combination of engineered barriers and the natural barrier provided by the host geological medium. The key engineered barriers are a stable waste form, either used fuel or vitrified waste from reprocessing used fuel; long-lived containers into which the waste form is packed; clay-based buffer materials that separate the containers from the host geological structure and control the movement of water to, and corrosion products away from, the containers; and seals and backfill materials to close the various openings, tunnels, shafts and boreholes. There is international consensus that this approach can best achieve the goal of safely managing used nuclear fuel in the long term. The biosphere, although not a barrier per se, is an important part of the overall system because it contains the pathways for direct exposure of humans and non-human biota to contaminants. Consequently, its study must be part of any waste management program. A variety of geological media are under consideration, including crystalline rock (Canada, Finland, Japan, Sweden and Switzerland), clays and shales (Belgium and Hungary), volcanic tuff (U.S.A.) and salt (Germany and Spain).

In many countries, the approach to development of the disposal concept has been to consider the performance of the system as a whole, rather than focusing on performance requirements for individual components. This approach allows flexibility in implementation to be retained and it increases the likelihood of identifying any counterintuitive interactions or synergisms among system components that could adversely affect safety. Thus, the performance of individual components, such as waste containers, is analyzed in the context of the system. The goal is to develop a thorough scientific understanding of the performance of the different components of a disposal system and how these components interact and influence one another, so that the overall system can be designed to provide defense in depth.

Acquiring and building the necessary knowledge base is a continuing process, and in implementing disposal, flexibility must be retained so that the program can use and benefit from new information and understanding over time.

To date, however, no country has demonstrated deep geological disposal and public uncertainty remains. This is fuelled in part by the public's mistrust of the industry and of governments, and in part by their fears of radiation and their scepticism about the industry's ability to safely contain its waste for periods of thousands of years. Thus, the challenge that faces society and those charged with responsibility for management of nuclear fuel waste is to develop sufficient confidence in the technology to permit decision-making, regarding the implementation of disposal.

Considerable efforts have been made to evaluate the behaviour of deep geological repositories with time, and their long-term safety. Scientific methods exist to establish the safety of particular disposal sites and there is an international consensus among experts that 'appropriate use of safety assessment methods, coupled with sufficient information from proposed disposal sites, can provide the
technical basis to decide whether specific disposal systems would offer to society a satisfactory level of safety for both current and future generations" [9].

Much of the evidence needed to evaluate any site that would be considered for deep geological disposal can be obtained from geologic information developed as the site is characterized. Field studies, including studies of natural analogues can extend the short-term evidence from the laboratory studies to the longer times of interest—tens and even hundreds of thousands of years—and provide systematic evaluation and verification of the understanding incorporated in the mathematical models used to assess long-term performance of a disposal system.

Incremental Decision-Making Process

In developing disposal facilities for nuclear fuel waste, a number of countries are following a strategy of staged or incremental decision-making, as an integral part of the process. Each phase, its review and subsequent decision-making should lead to an increased confidence in the technology. This is the case in the evolution and development of national programs in Belgium, Canada, Finland, France, Spain, Sweden, Switzerland and the U.K. By proceeding with the development of waste management technologies in a staged manner, assessing safety can be separated from the implementation activities that often create public concern, such as the siting of a facility.

While the details vary from country to country, the basic elements involved in achieving disposal are:

- Conceptual and technology development/demonstration, followed at the appropriate time, by site-specific activities beginning with site screening, to select one or more sites for detailed surface-based characterization studies.

- Surface-based site characterization leading, with appropriate review, to a selection of one or more sites for exploratory excavation and more extensive in-ground characterization, or to a decision to abandon the site.

- In-ground characterization studies leading to a decision, following appropriate reviews of the status of our knowledge, to initiate construction and then operation of a repository. During characterization, a site-specific facility would be designed. At this stage, performance assessments would also be done to assess the long-term performance of a facility at a given site with a given design.

- Construction and operation of a facility which will unquestionably involve ongoing review, reassessment and recommitment, leading, if appropriate, to continued operation and eventually to a decision to cease operations and decommission. Initial operation of any facility will likely involve a demonstration phase. Sweden, for example, is planning on a demonstration emplacement of waste in a deep geological repository by about 2010. At an early stage of repository construction, possibly during the demonstration phase, or as part of sub-surface characterization studies, an area of the repository could be dedicated to component testing in the actual conditions at the site. Such testing might continue over the many decades of operation, and as part of confidence building, the components could be eventually retrieved and examined to establish how closely their behaviour conformed to the anticipated performance.

- Decommissioning and eventually, the sealing of all shafts, tunnels and exploratory boreholes to close the facility and to place it in a passively safe state. The results of component testing, operational reviews and monitoring, and post-operational monitoring would form the basis on
which to make a decision when to close and seal the repository. The long-term safety of this system would need to be convincingly demonstrated, prior to closure.

This approach would utilize the observational method where information is continuously acquired and incorporated into the design. The observational method is central to the use of performance assessment analyses as part of the design and implementation process. Beginning during the site selection phase, assessments are made of the site condition using all available data. The understanding of the site is incorporated into models for use in design and in performance assessment studies.

Both the designs and the assessments become more refined as the knowledge of a site increases. As work proceeds, observation and evaluation of the actual conditions encountered are compared with the previous understanding which, if necessary, is then modified. This cycle continues throughout site selection, construction and operation, so that at each point when significant licensing and operational decisions need to be made, a long record of observation and a series of increasingly refined performance assessments are available on which to base the decisions.

Throughout this process, regulatory standards would apply and regulatory approval and licenses would be required at various points in the process. An extensive monitoring program beginning with the start of site screening activities, would be maintained throughout the process. Many years' worth of data from monitoring and studying the site and a series of increasingly refined evaluations would have been accumulated before the decision would be made to emplace the waste. After the repository had been filled with nuclear fuel waste, it would likely be maintained under surveillance for an extended period to confirm that it was behaving as intended. The decision whether or not to close the repository would then be made on the basis of the accumulated evidence and experience from the site selection, construction, and operational stages, a process extending over many decades.

Throughout the process, judgements regarding the performance of the disposal system would be based on an ever-expanding knowledge and experience base, a knowledge base that should lead to progressively greater confidence. Although uncertainty could not be entirely eliminated, the long history of past performance should provide the basis for building both public and technical confidence in the site and its future evolution, and the long-term safety and the performance of the facility.

This approach provides ample opportunity for ongoing review, and at any point in the process, if ongoing review and assessment indicates the objectives of safe disposal cannot be met, it is possible to cease operations and retrieve the waste.

Public Involvement

In OECD countries, and increasingly in other countries of the world, decisions on implementing new technologies and siting large-scale facilities, even facilities that do not involve hazardous materials, can no longer be made based solely on technological considerations. For example, in Canada, where the concept for deep geological disposal of Canada’s nuclear fuel waste is currently undergoing a review under the federal environmental assessment review process, the Guidelines for the Environmental Impact Statement [10], that the proponent is to submit to the review panel, noted that:

"Ethical and moral perspectives, along with various social issues, as evidenced by presentations to the Panel at the scoping meetings, are as important as scientific, technical and economic considerations. The proponent should investigate how relatively narrow and
focused considerations of a scientific, technical or economic nature should be viewed in the much broader context of ethical, moral and social considerations."

The process for establishing disposal facilities therefore requires consultation with, and the active participation of, a wide spectrum of society. This includes the waste management agency itself, which must have confidence in the safety and environmental performance of the system, since it is accountable for this performance. It involves the technical community who need to be assured, and who need to provide assurance to others, that the technical basis is sound and supportable. It involves regulatory agencies who need assurance that the risks to society and to the environment can be managed. It involves the community that will host such a facility who need near-absolute assurance of safety, but who also have concerns about a wide range of other possible impacts such as employment, property values, quality of life and change. It involves politicians who are accountable to their constituents, and in the end, it involves society at large who are concerned about issues such as safety and economics, but who also require that the broader ethical and environmental issues be addressed and that due process be followed.

Due process requires that siting practices be open and participative and that waste management agencies develop and maintain effective working relationships with potential host communities and with communities along transportation corridors. For these relationships to be effective, the waste management agencies must demonstrate a commitment to principles of fairness, openness, shared decision-making, and above all to safety, so that affected communities can participate appropriately in decision-making.

Conclusion

Since the inception of the nuclear power industry, the industry has shown environmental leadership by containing its radioactive waste using safe management practices. The industry has also recognized the need to establish a passively safe, long-term method of isolating the waste from the environment. It is, I believe, in the forefront of managing and accounting for its full life-cycle costs, including environmental costs.

The incentive for selecting a permanent disposal concept to manage long-lived nuclear fuel waste is derived from two fundamental ethical principles:

- the waste must be managed in such a way that human health and the environment are protected in both the short- and long-term, and
- as the principal beneficiaries of the energy which gives rise to the waste, our generation should assume, to the extent possible, the burden of managing the waste.

Minimizing the burden on future generations means more than simply making financial provisions. It means developing and demonstrating the technology to implement disposal, to the extent reasonably possible; it means ensuring that the technology can be implemented in such a way that future generations retain options and flexibility in their decision-making; and it means proceeding toward implementation without unnecessary delay.

All countries that have nuclear power programs are proceeding towards disposing of their fuel waste to respond to public concerns about nuclear energy. The waste exists, and definitive solutions for dealing with it must be implemented whether nuclear power generation programs are to be continued, expanded, or even phased out.

The waste may take either the form of used fuel or suitably stabilized waste from fuel reprocessing. The nature of the disposal and details of the disposal systems used will depend to some
extent on whether or not the fuel has been reprocessed, but based on current regulatory requirements, it appears that all waste contaminated with other than small quantities of long-lived nuclides will require deep geological disposal.

Treatment of used fuel by reprocessing, possibly augmented by partitioning and transmutation of long-lived radionuclides, does not obviate the need for deep geological disposal.

The public and decision-makers have a right to expect, today and in the future, that industries will respect the goal of sustainable development. For the nuclear industry that means that we must continue to make progress towards isolating our hazardous waste materials from the environment for as long as they remain hazardous. But it also means that we must ensure that our approach is based on a sound and coherent ethical framework, and that is the issue we will explore over the next two days.

References


SESSION 1

BACKGROUND TO CURRENT ENVIRONMENTAL POLICIES AND THEIR IMPLEMENTATION
Evolution and Current Thoughts about Environmental Policies

Bill L. Long
Director for Environment
OECD Environment Directorate

On behalf of the OECD Environment Directorate, I am pleased that Dr. Morgenroth and I have been invited to participate in this workshop.

I say this, in particular, because I find it unfortunate that OECD's Environment Policy Committee, for a variety of reasons, continues to resist engaging the Nuclear Energy Agency in joint work on nuclear energy issues. The matter of nuclear waste disposal is clearly a critical public policy issue that deserves a truly "collective" opinion. I thus hope that our presence here today - as OECD Secretariat members in our own capacities - will help pave the way for expanded collaboration in the future.

We have been invited to present an overview of trends and current thinking in environmental management, broadly defined, as a context for your consideration of the environmental and ethical aspects of the disposal of long-lived radioactive wastes. I will try to set out a general framework of the principles and strategies which have been, and are being, used by OECD Member countries to manage environmental problems and risks. Dr. Morgenroth will then focus explicitly on the management of non-nuclear toxic materials and hazardous substances.

One way to address this subject is to examine the changes in environmental policy-making over the last three decades, beginning in the mid-1960s when environmental concern first began to emerge in a major way in OECD countries.

At that early juncture, roughly from about 1965 to 1975, environmental awareness and government policies were largely focused on locally-derived pollution detectable by the human senses - pollution which could be seen, smelled or heard. Industry was widely perceived to be the principal villain; "clean-up and cure" was seen as the challenge; and government "command and control" regulation was the policy response of choice.

There were also two interesting counter-currents. On the one hand, the "Limits to Growth" world model was embraced by many, with its projections of the collapse of economic, social and environmental support systems from the onslaught of population growth, industrial pollution and natural resource consumption. On the other hand, there seemed to be a vast reservoir of usable space for man's waste products. Smokestacks were thus built higher, and sewerage outfalls extended into marine environments, based on a belief that "the solution to pollution is dilution".

By the mid-1970s, environmental policy-making became more sophisticated and also much more complex and uncertain.
The emergence of transboundary environmental problems - notably acid rain and river pollution - raised both ecological and political challenges for environmental policy-makers. Solving one's own problems through dilution and dispersion became much less of an acceptable solution.

And, when situations like the "Love Canal" episode in the U.S. alerted citizens there and elsewhere to the fact that their residences might have been built on top of old toxic wastes dumps, there was a strong public backlash to any type of "out of sight, out of mind" approach to pollution control and waste management. This experience has, I believe, important implications for the management of radioactive wastes, particularly if the public is expected to "buy in" on a non-retrievability approach to deep geologic disposal of wastes of almost any type.

The period from 1975 to 1985 was thus characterised by a move toward "multimedia" approaches to environmental management, based on concern that earlier strategies were merely moving the pollution back and forth among the air, water and land media. Further, the "react and clean up" approach gave way to the philosophy of "anticipate and prevent".. buttressed by projections of both significant environmental benefits and substantial economic savings.

The public attitude was that industry had to be pushed, and if necessary compelled, by government to find ways to produce goods and services with less pollution, resource inputs and waste generation. Fully closed manufacturing processes were seen as a proper goal.

Driven by the growing complexity of the environmental threats, the rising costs of pollution control, and the need to find ways to promote development of cleaner technologies, government policy-makers undertook programmes of "regulatory reform" - and also began to experiment with the use of "economic instruments" (e.g., taxes and charges).

Risk assessment and risk management came into vogue during this same period, particularly to cope with environmental threats which expressed themselves at microscopic levels - pollutant levels undetectable by the unaided human senses. The challenge here - and one that remains relevant today, particularly for the nuclear industry - was reflected by Lee Thomas, former head of the U.S. Environmental Protection Agency who used to agonize (privately and publicly) about the fact that the priorities for environmental risk recommended by his science advisory committee were almost the complete opposite of what the public and the Congress perceived as the major risks. He complained that just the slightest hint that some pesticide might pose a cancer risk ... regardless of the odds ... was enough to set lawmakers running to draft complex and costly legislative remedies.

Let us now move to the last ten years, and consider the recent evolution and transformation of environmental issues and strategies. In particular I will highlight several major current trends that I believe may have consequences for the disposal of long-lived radioactive wastes.

Among the "defining" developments since 1985 have been: the publication in 1987 of the report of the World Commission on Environment and Development, prescribing the "Sustainable Development" world model; the expansion of environmental concern to encompass global-scale threats, ozone depletion and climate change in particular; the 1992 "Earth Summit" in Brazil; and a recent recession in OECD countries which has challenged the staying power and resiliency of public support for environmental protection.

The "Precautionary Principle" of environmental management emerged during this same period, adding to what is really a rather small set of environmental principles. Other notable principles are the "Polluter Pays Principle" of the early 1970s which is, in effect, a principle of non-subsidization of polluters; and a somewhat less codified and less accepted "User Pays Principle" of the s, promoting full-cost pricing of natural resources. The Precautionary Principle, which calls upon policy-makers to take prudent preventive action to deal with potential environmental risk in the absence of compelling...
scientific evidence to the contrary, remains controversial. It does command quite widespread support internationally, and hence is a difficult barrier to surmount for certain types of proposed activities. This has obvious implications for nuclear waste disposal.

As we in the OECD address environmental issues today, we identify a number of trends that will likely be key determinants of environmental policy-making throughout the remainder of this decade, and into the next millennium. Each has, I believe, potentially important implications for nuclear energy, including waste management.

The first trend is that a much longer-term time horizon is beginning to be applied to environmental planning and assessment. Stimulating this is (1) the requirements of the Sustainable Development strategies called for at the Earth Summit in Rio, which virtually all countries are grappling with; and (2), the time dimensions required to cope with the climate change threat.

This holds out both promise and problems for radioactive waste disposal. Taking a longer-term look into the future has given rise to the issue of "intergenerational equity", an issue well-covered in the excellent background document prepared for this workshop.

Certainly the contention that deep geologic disposal of radioactive wastes just unloads the problems on future generations will not easily be dispelled. One might also point out, however, that future generations will not only absorb costs but will also reap benefits from the development of the nuclear energy option, and the associated environmental safeguards, created in the last half of the 20th Century. Balancing costs and benefits thus should become the issue; although cost-benefit calculus is invariably contentious when applied even to traditional environmental issues.

The matter of intergenerational equity - how to interpret it and how to provide for it - is hotly debated today within the environmental community, with no clear consensus and guidance in hand. The issues go well beyond the nuclear area, obviously, involving such considerations as clearing of forests, draining of wetlands, and covering rich topsoil with urban settlements.

On the more positive side, this longer-term view of environmental challenges and development needs is focusing a spotlight on the pivotal role played by the energy sector - as both the solution and the problem - and particularly on the need to move societies away from fossil-fuel based energy sources. As one looks at realistically available options over the next century, nuclear energy (from fission and fusion) appears on most of the lists I have seen.

A second current and notable trend involves a renewal of interest in finding technological solutions to environmental problems. As testimony to this, even a cross-section of environmental activists now appear to accept the fact that the goal of Sustainable Development can only be reached through a new technological "revolution", one designed to permit expanded production with much reduced throughputs of raw materials and outputs of pollution and wastes.

Governments are thus examining their role in stimulating the development and transfer of "cleaner" technologies; and part of the OECD's environmental work programme is designed to assist in this effort.

There may be an important consideration here for nuclear waste disposal strategies. The environmental community is placing great stock on an evolutionary form of technology that will enable ever-higher environmental quality to be achieved, and to move toward total reduction of pollution and waste generation. If deep geologic disposal of nuclear wastes were to be proffered as the "final" solution, it would likely be challenged from some quarters on the basis that this would have a chilling effect on investments in next-generation waste management strategies and technologies which might provide even better environmental safeguards.
A third noteworthy trend in environmental management is the high priority governments are attaching to finding ways to achieve environmental goals at lowest cost. This reflects the rising cost of environmental protection at a time of budget stringency, and also attests to the fact that environmental protection remains a priority concern of governments.

Efforts to lower costs are underway on two fronts. One involves the greater use of markets to achieve environmental goals, involving eco-taxes, pollution charges, tradeable permits, deposit-refund schemes, and the reform of national tax systems - to cite some of the most widely used tools. The OECD has just published an updated assessment of the use of economic instruments in OECD countries. One of our conclusions is that environmental policy-making in the years just ahead will be based on trying to find judicious combinations of government regulations and economic instruments to solve particular problems. There is indeed no evidence that regulatory approaches are being replaced, despite the theoretical advantages that market-based measures seem to have.

A second way of lowering environmental protection costs is to find and remove policy conflicts. Here the focus today is on examining key economic sectors - manufacturing, energy, transport and agriculture - with a special priority attached to assessing the environmental implications of production-based subsidies. It seems likely that this analysis will be deepened and extended, with policy-makers seeking clarification of, for example, what are the "true" economic costs to society of different energy sources.

A final trend worth noting for this gathering involves what has been called a "new partnership" among government, industry and environmental interest groups. At the Earth Summit in Rio two years ago, a business representative said that, in his view, the evolution of environmental management can be described as the "three Ds". "The 1970s were the age of Denial, with industry arguing that it was not to blame. The 1980s were the age of Data, with government and industry debating over whose data was better. But, the 1990s appear to be the time of Dialogue, with all parties agreeing that there is more reason to work together than to argue apart." I believe that this is a pretty good encapsulation of where we are today.

Last December, OECD's Environment Policy Committee discussed the question, "How are we doing within the OECD family after two-plus decades of investment in environmental protection?" The strong consensus was that we are really not doing too badly in the manufacturing sector, with significant improvements evident in pollution control and waste generation. The major challenges were seen as controlling dispersed, non-point pollution sources, particularly in the agriculture and transportation sectors.

This perspective - that industry can get it right, especially with respect to controlling pollution related to fixed installations - would seem to offer some interesting prospects for the nuclear industry.

I should hasten to point out, however, that environmental NGOs and Parliamentarians are applauding industry for their efforts to reduce waste generation at the source - and not for being innovative in their ability to dispose of unwanted residuals.

Finally, allow me just a brief word about the matter of ethics in environmental management. Ethical concerns have been raised by many parties, on a spectrum of issues, over the past three decades, with varying degrees of impact on policy-making. I frankly have never heard a coherent discussion of this, and thus look forward in particular to what will be said about the subject in this workshop.

Let me simply point to a number of environmental issues which have stimulated debates on ethics. The use of laboratory animals for the testing of chemicals is one that comes quickly to mind. OECD's work on chemicals management has been, in part, designed to help reduce such testing.
Then there are the ethical considerations associated with the possible elimination of other species of animals through hunting, which have led to international treaties to protect threatened or endangered species. International whaling bans are now apparently based on ethical grounds, since certain species of whales are continuing to be protected even in the face of scientific evidence that the species are not endangered.

Ethical arguments continue to be raised against international trade in hazardous chemicals and dangerous products by a country that has banned such commodities for its own domestic use. Here the outcome, in terms of changing policy, has been mixed.

Objections on ethical grounds are also being heard, and examined by Environment Ministries, to the perceived preponderance of sanitary landfills and waste disposal sites in the poorest parts of towns and cities. Other examples include claims by environmental NGOs that tradeable emission rights schemes for managing pollution are simply unethical grants to industry of the "right to pollute"; and claims by developing countries that the "North" is consuming an unethically high proportion of the earth's "environmental space" and natural resources base.

So, as you consider the ethical aspects of the disposal of long-lived radioactive wastes, you may be assured that ethical assertions and considerations enter into many types of environmental debates.

However, the resolution of environmental issues invariably is hammered out in what has been called "the crucible of public policy"; and the weight given to ethical concerns seems to vary from issue to issue, from culture to culture, and from time to time.
Managing Hazardous Activities and Substances

Victor H. Morgenroth
OECD Environment Directorate

Background

On behalf of the OECD Environmental Health and Safety Division of the Environment Directorate, I am pleased to have been invited to be a member of the small group that assisted with the preparations for this Workshop on the Environmental and Ethical Aspects of Long-lived Radioactive Waste Disposal. My thoughts about the aims and contents of this paper began to evolve following a meeting last April of the workshop preparatory group. That meeting was the beginning of a valuable educational process for me involving, first, a recognition that there are a number of preconceptions of the similarities and differences of certain aspects of the management of hazardous activities, products, and wastes depending on whether you have been brought up in the nuclear and chemical cultures. Second, there is a great deal of benefit to establishing a continuing dialogue and exchange of ideas, concepts and even technical information on the approaches and methods used in each culture for the assessment and management of health and environmental risks.

The primary purpose of this paper is to provide background information for this workshop that is focused on the process, principles and policies being employed in OECD Member countries for managing hazardous activities (non-nuclear) and products involving chemicals (non-radioactive). In addition, I will try to highlight certain areas in the risk management process where certain assumptions and conclusions maybe of particular relevance to the goal of a review, reconsideration and restatement of the strategy of geological disposal of radioactive wastes (DISPOSAL OF RADIOACTIVE WASTE: Can Long-Term Safety Be Evaluated, OECD 1991).

As a point of departure, I undertook a comparison of the different chapters of Agenda 21 of the Earth Summit, The United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in June 1992. One difference that emerges from such an analysis is the priority assigned to waste minimization and the introduction of new technology for non-nuclear waste management (e.g., the introduction of cleaner technologies into production processes or waste treatment) appears to be much less in nuclear waste management. This is illustrated by the language used in the different Chapters of Agenda 21 devoted to the management of hazardous non-nuclear material and wastes (chapters 19: Environmentally Sound Management of Toxic Chemicals, Including Prevention of Illegal Traffic in Toxic and Dangerous Products, Chapter 20: Environmentally Sound Management of Hazardous Wastes, Including Prevention of Illegal Traffic in hazardous Wastes, and Chapter 21: Environmentally Sound Management of solid Wastes and Sewage-related issues) and to the management of radioactive wastes (Chapter 22: The Safe and Environmentally Sound Management of Radioactive Wastes). In Chapter 19, minimization of waste in production is mentioned 57 times, recycling is mentioned 14 times, and the introduction of new, cleaner technologies is mentioned 35 times; where as, disposal is mentioned 11 times. In contrast, Chapter 22 mentions disposal 14 times, minimization is mentioned only twice and technology is mentioned once in the context of processing, conditioning, transport and ultimately disposal.
Managing Hazardous Activities and Substances: the Process

In the broadest sense managing non-nuclear hazardous activities and substances involves a process which includes a number of activities:

- Identification
- Hazard/Risk Assessment
- Risk Management
  - Signification (Valuation)
  - Discrimination
  - Implementation (Compliance)
  - Assurance
  - Monitoring
- Risk Communication

This process is used to serve a variety of purposes. For example, the determination of potential adverse health and/or environmental effects associated with a particular activity (e.g., municipal waste incineration) or a substance (e.g., mercury) in order to undertake actions to mitigate the occurrence of such effects; comparison of technological alternatives in order to ascertain the effectiveness of different control or mitigation techniques designed to reduce a certain risk; and, evaluation of the magnitude and location of the effects resulting from potential accidents based on different possible scenarios in order to select sites for a potentially hazardous facility.

Identification involves a determination whether the degree of concern, associated with the potential risks to health and the environment posed by a particular activity or substance, warrants further scrutiny with respect to the need to manage or reduce the risks presented. Normally such determinations are made via administrative or legal caveats based on past experience as well as technical or scientific information related to the possible occurrence of harm to human health or the environment from certain types of activities or classes of substances. The administrative or legal requirements normally include provisions calling for hazard/risk assessment and the development and implementation of appropriate measures for risk management, control or reduction. Such provisions normally cover large groups or classes of activities (e.g., facilities were hazardous substances are handled, chemicals added to food, drugs, new industrial chemicals). Examples include: legislation requiring the assessment of potential health and environmental risks of new chemicals prior to its manufacture and use; administrative procedures associated with granting building permits or land-use permission for facilities involving the presence and handling of hazardous materials; and the assessment of the possible environmental impacts of new technologies that may alter the normal background levels of exposure of humans or the environment to hazardous environmental constituents.

Hazard/risk assessment involves evaluation of both the potential of a chemical to harm man or the environment and the potential for exposure to the chemical. Evaluating the potential for exposure includes defining the exposure conditions under which harm is likely to result. Where possible, in the course of hazard/risk assessment, the uncertainties associated with these evaluations are identified along with specific target characteristics and the expected incidence and severity of potential hazards. Aspects such dose-response relationships and inter-species extrapolations are also important in this context. Since clear and valid human data related to the risks of hazardous substances is available only in rare situations, inter-species extrapolations is one of the more uncertain and most contentious areas in hazard/risk assessment. Interestingly, this does not seem to be a
significant issue in the context of the review and reconsideration of the strategy of the geological disposal of radioactive wastes.

In hazard/risk assessment activities there is often a direct relationship between disagreement and controversy, and uncertainty. Thus "managing" the degree of uncertainty is a critical factor in most assessments and the acceptance of assessment results. Important to this process is the identification of assumptions made in a clear and transparent manner; the determination of the "sensitivity" of assessment results to changes in the assumptions; an evaluation of the quality of the data used in the assessment (including the rationale for selection of "critical" studies and for the rejection or limited use of other data; as well as efforts to ensure that further data requests will actually lead to a reduction in uncertainty when such data is generated and evaluated.

Another significant component of the hazard/risk assessment process is Exposure assessment. It involves the determination of the extent of human and environmental exposure to hazardous substances before and after the application of management or control options. It includes source/release assessment, i.e., estimating the amounts, frequencies, and locations (e.g., the workplace, the home, indoors or outdoors) of the introduction, release or escape of material of concern from a specific source into a variety of environmental media (e.g., air, water, biota); the estimation of probable quantities; duration; concentrations in various media; transport between media; and, the environmental fate of the potentially hazardous material released. Such information is related, in part, to the environmental conditions at the time and place of the release. Exposure assessment should provide quantitative data on individuals, populations, or ecosystems that are, or may be exposed. Confidence in the data derived from exposure assessments is critical to not only the acceptance of results of the risk assessment but also to estimating the effectiveness of any risk management measures. This area of hazard/risk assessment is likely to be highly significant with respect to the identification of alternatives for the disposal of radioactive wastes.

Multi-exposure analysis is a technique that considers the different pathways through which exposure to chemicals may occur. Traditionally, exposure analysis is performed in some detail for human exposure to chemicals in food or drinking water or at the workplace. In order to derive a complete picture of exposure all routes, or parts of those routes, that pose a significant risk of exposure of selected human or environmental targets to a chemical must be identified. For the environment, exposure via environmental media (air, water, soil and biota) must be analyzed; for humans, exposure via consumer products or other materials (e.g., drinking water) should be considered as well.

The effectiveness, efficiency and confidence in managing the risks of an activity or hazardous substance depends on the amount and quality of data available and on the results of hazard/risk assessment. Improved assessment practices lead to better management of the risks identified. Since they provide the basis for risk management, it is desirable that hazard/risk assessments be performed in such a way that the objectives and requirements of risk management are taken into account.

The general objectives and requirement of risk management are derived from the broader environmental and health goals and policies that Mr. Long set out in the previous paper. The concepts of "Sustainable Development", the "Precautionary Principle", longer-term time considerations, balancing present and future risks, costs and benefits, sectoral integration find and remove policy conflicts and the increasing use of clearer technology market based incentives and other economic instruments in conjunction with regulation. The greatest impacts of these policies is on the breadth of information concerning an activity or hazardous substance needed for the more comprehensive assessments required to reflect new concerns and policies. Potentially hazardous activities and substances are now assessed not even from cradle to grave but from conception and design to possible impacts long after ultimate disposal.
**Risk Management** activities involve integration of the results of hazard/risk assessments with other technical, social, economic and political considerations. Once the risk has been determined — i.e., the probability that hazards will occur under specific exposure conditions — the following activities or steps can be taken.

**Signification (Valorization)** involves a determination of the gravity and acceptability of a given level of risk based on the results of hazard/risk assessment. This is an activity in the process of managing the risks of hazardous activities and substances that is beginning to receive greater attention from the public as well as policy-makers that it has in the past. Considerations in this area involve a number of the societal and ethical issues set out in the Background Document for this workshop. It is in this area that there is the greatest similarity between the nuclear and chemical cultures in that the interface between science, policy and public perception is poor to non-existent.

**Discrimination** includes the choice of appropriate and realistic management, control or risk reduction measures. This choice takes statutory requirements into account and considers combinations of measures such as regulatory actions, socio-economic incentives, and voluntary or negotiated agreements and requirements for effective provision of information.

Discrimination involves the development of alternative risk management strategies designed to avoid or reduce significant risk. Such strategies can include establishment of exposure limits; direct control of emission from sources; control of use, ranging from partial restriction to total ban; protection of the exposed target; and hazard warnings. The range of risk management measures covers precautionary, advisory or educational strategies as well as stringent regulatory controls.

Analysis of other factors, such as the availability of the control or cleaner technologies or safe substitutes; the enforceability and cost of control measures; socio-economic implication of the various actions or of taking no action; and public perception of the risks and benefits of the measures, need to be considered in the decision-making process in order to evaluate the overall feasibility of each option.

**Implementation (Compliance)** involves the execution and enforcement of the measures chosen.

This step is followed by **Assurance** of compliance with, and **Monitoring** the effectiveness of, control measures, the latter in terms of protection of health or the environment. In terms of present policies related to measures calling for the sequestration of non-nuclear hazardous substances continuous monitoring of environmental media near the site is usually mandated. On the surface, this appears to differ from previous thoughts concerning the strategy of the geological disposal of radioactive wastes.

**Risk Communication** is the part of the management process that involves the effort to exchange information concerning risks. The assessor of risk attempts to convey, to a variety of stakeholders, information about the extent and nature of a health of environmental risk. This usually includes description of the significance of the risk as well as the decisions, actions and policies to be employed to manage or control the risk. The media is often an important channel of information to the public about a risk. There have been numerous analyses of risk communication, most of which point to the problems and pitfalls and not the few successes that have occurred. In 1988 the Environmental Protection Agency of the United States published a set of rules for effective risk communication:

- Accept and Involve the Public as a Legitimate Partner
- Plan Carefully and Evaluate Performance

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- Listen to your Audience
- Be Honest, Frank, and Open
- Co-ordinate and Collaborate with Other Credible Sources
- Meet the Needs of the Media
- Speak Clearly and with Compassion.

For each of these rule the Agency published guidance on how to fulfil the risk communicator’s obligations to the recipients of information.

Managing Hazardous Activities and Substances: Policies and Practices

Risk management measures for specific chemicals can be quantitative in so far as they aim at specific desired levels of risk reduction. Examples are air or water quality standards; permissible emission concentrations; permissible concentrations in food for pesticides or food additives based on acceptable daily intakes or residues; and, workplace standards based on threshold limit values. In general, these are control measures which are required or recommended by governments for specific chemicals and are based on detailed reviews of exposure and toxicity data in the form of an hazard/risk assessment. Due to the quantitative target levels of the risk reduction specified, enforcement of this kind of control measure is generally relatively easy. Its effectiveness is usually determined by monitoring the extent of the reduction in exposure to humans or in levels in the environment.

More general types of risk management measures which can be applied to specific chemicals include labelling requirements; material safety data sheets; use registration; and recommended conditions for use. Such measures which do not specify target levels for risk reduction, are also generally imposed or recommended by governments, often after consultation with industry. They are based on limited evaluations of use patterns and/or of one or more toxic responses. Enforcement of these kinds of measures for specific chemicals is relatively easy, as is determination of compliance with them. Due to their precautionary nature, quantitative monitoring of their effectiveness is more difficult.

Similar general risk management measures, which are usually applied to all chemicals or to groups of chemicals, include licensing requirements for the users of certain products (e.g., pesticides); codes of practice for industry; training of users; and consumer awareness programmes. Such measures usually rely on the responsibility of industry and on the competence and knowledge of handlers of chemicals. These measures are often developed through co-operation between government and other parties involved. They are usually based on general information on the handling and use of classes of chemicals and on broad toxicological principles. Neither their enforcement, nor determination of compliance with them, is easy. Quantitative monitoring of their effectiveness is difficult.

Management of chemicals often focuses on the risk caused by a specific use (e.g., food additives, drugs or pesticides); by a specific source (e.g., factory releases); or to a specific medium (e.g., air or water). The resulting control measures usually focus on particular populations (e.g., consumers, workers, ecosystems or species) or on a specific phase of the life cycle of a chemical. Management of these risks by either specific or general measures has been successful in the past and will continue to be an important way to protect human health and the environment.
However, the effectiveness of managing the risk of chemicals in these specific ways may not always be optimal. Various uses, sources and exposure routes can play a significant role in the total risk that some chemicals pose. (e.g., the various sources, uses and exposure pathways for elements such as mercury and cadmium). By focusing only on specific risks, other important pathways or sources of exposure, and their interaction, may be overlooked and fully effective control measures therefore not instituted.

More comprehensive risk assessment and management policies and practices, consistent with concepts of "Sustainable Development", are now being used to address the reduction of the total risk posed by chemicals which are used extensively and/or distributed widely in the environment. The basis for these approaches to the management of hazardous activities and substances is the evaluation of the commercial and environmental life cycle of a chemical together with multi-exposure analysis.

Use of these approaches increases the need for interaction among the different authorities in Member countries involved in chemicals control. Examples of activities undertaken to improve coordination of administrative practices and statutory requirements are given below. Such activities address, e.g., the coherency of different regulations; timing (or sequence) of regulation; harmonization of permitting procedures; duplication of efforts for information gathering and assessment; and the coordination of the setting, implementation and enforcement of standards at the national, regional and municipal levels.

These more comprehensive approaches do not require that every possible detail be investigated and documented in a completely quantitative way. Indeed, the data needed for a fully comprehensive approach are often inadequate or incomplete. Methods exist for estimating some of the data or for making use of assumed values or scenarios. The total risk posed by a chemical can be taken into account by using such methodologies should the validity of the method and the need to approximate missing data justify doing so. Through the use of such approaches, risk reduction or management measures can be developed as an alternative to taking no action because data are inadequate, or to taking actions that deal with only part of the total risk.

In analysing a chemical's commercial life cycle, its various stages (manufacture, storage, transport, use and disposal) are evaluated in order to systematically identify the sources of exposure and nodes of risk. All sources of release to the environment — before the commercial introduction of the chemical, during its consumption, and via waste — are considered and assessed with respect to their contribution to the total release. In so doing, account is also taken of the relative importance of the various releases during the entire commercial life cycle.

The environmental life cycle is evaluated by examining the transfer of a chemical between environmental media after its release and the transformation processes occurring in these media. Most heavy metals and many organic chemicals are found in significant amounts in more than one medium. An analysis of the environmental life cycle contributes to the identification of measures that can be aimed at the most significant media; at the same time, it can ensure that measures are taken which result in real risks reduction rather than merely shifting of the substance and associated risks from one medium to another.

Unlike nuclear materials, for most chemicals there is very little safety data available, sometimes none at all. The potential risks posed by these chemicals are managed differently from those of chemicals for which more safety data are available. In-depth analyses are obviously not possible, nor can control measure which requires quantitative specification of risk reduction be employed in the absence of adequate data. In-depth analyses are obviously not possible, nor can measures which require quantitative specification of risk reduction be employed in the absence of adequate data.
General management practices are used for these chemicals until more information is available for development of specific policies.

Risk management in the absence of extensive data is similar in several respects to the management of non-nuclear hazardous waste. For waste, data on composition and toxicity are often lacking but general policies concerning its treatment and disposal are nevertheless implemented. These policies usually deal with categories of wastes which are identified based on general criteria like the origin of the waste; the basic characteristics of the process by which the waste is produced or the likelihood that the waste contains certain specific hazardous substances. Under such an approach, all of the usual steps of the risk management process are not followed. Policy decisions are often based largely on experience with management of similar materials and on general principles.

Likewise, for management of chemicals in the absence of data, an attempt is made to deal with chemicals in general, or with a specific group of chemicals, in order to reduce the total exposure burden. Such groups of chemicals can be established, based on: similar uses; similar behaviour in their commercial or environmental life cycles; or in parts thereof; or a similar potential for toxicity. Examples of the kinds of chemicals of which the risks have been managed in this general way are: natural products, synthetic flavours, industrial chemicals, intermediates, polymers, low-volume chemicals and research chemicals. Many Member countries have begun programmes aimed at inventories of potentially toxic chemicals. Most of these programmes call for reduction in the emissions of the chemicals listed. These "Pollution Prevention Programmes" usually involve issuing estimates of the quantities of hazardous chemicals released by a industrial entity to the public and voluntary commitments on the part of industry to reduce emissions by a specified amount over a specific time period.

The risk management of chemicals in the absence of extensive data is a developing area which will become increasingly important as large numbers of chemicals with little data are identified in the systematic investigation of existing chemicals. Only limited information and experience are available in this area to date. Many of the precautionary measures described above can be applied. Although there are many more chemicals without extensive data than there are chemicals which have been subjected to the more comprehensive approaches to manage risk.

Several Member countries are developing more integrated and comprehensive policies for risk management. A number of new arrangements involve modifications of administrative practices. The various initiatives relate to specific chemicals or industry sectors; to specific agencies or ministries (or groups thereof); or to all parties involved in managing chemical risks. Some approaches being used are:

- addressing a group of chemicals with the same use pattern simultaneously (e.g., chlorinated organic solvents), taking into account possible shifts in use pattern or increased use of alternatives resulting from various control actions;
- addressing a particular industrial sector and developing an overall plan for implementing a number of environmental measures over a certain time period, rather than introducing various new measures on an ad hoc basis;
- developing a policy of "best practicable environmental options" seeking a concerted approach to problems of air, land and water pollution;
- instituting a co-ordinating body within an agency or ministry to review proposed risk management measures originating from its various sections;
— developing a multi-year programme which integrates the policies of the (sections of) ministries involved;

— instituting within government an authority which can co-ordinate activities concerning chemicals undertaken by different agencies or ministries, and

— instituting an advisory group of representatives from government, industry, trade unions, environment groups and consumers to address general aspects of chemical risk management.

This list is incomplete. Other innovative activities in this area are being initiated in Member countries. Even though the exact scope and detail of the activities have not been elaborated here, their existence shows that relevant initiatives are being taken as health and environmental policies evolve.
Emerging Concepts and Requirements for the Long-Term Management of Non-Radioactive Hazardous Wastes

Would Geological Disposal be an Appropriate Solution for some of these Wastes?

Kristina von Rein
Swedish Environmental Protection Agency
Section for Hazardous Waste and Site Remediation

As a result of industrialization, population growth and the rapid development of technology, man has had a growing impact on the natural environment. The environment has not been assigned a price and has consequently been overexploited. Environmental legislation and other measures have brought about considerable progress, but we still have a long way to go before we - producers and consumers alike - can be said to have assumed full responsibility for the environmental effects we cause.

Environmental policy must be preventive and long-term. It must ensure that the interests of future generations are taken into account in decisions made today. In order to find solutions to environmental problems we must look not only to the technical causes, but also to the underlying economic, political and social mechanisms. There is a need for changes in economic signals and in political and social patterns to encourage environmentally sound technologies and environment-friendly behaviour. And this takes time, time to change the way we think and the way we act. This in turn requires a broad-based knowledge of and commitment to environmental issues, so that environmental interests can make themselves heard over other interests. This is true of the environmental field in general, and it is also true within the field of waste management.

Waste is something that has always followed in the wake of human activities, but the content and amount of the waste has changed with time, reflecting the development and industrialization of society. Our modern production and consumption society gives rise to very large quantities of waste, and in many cases the waste contains a large amount of metals and chemicals. Waste is something we want to get rid of. But today's society is finding it increasingly problematical to get rid of it.

We still need to know more about the toxicity of different substances, their transport pathways to and in the environment, and their effects on human health and the environment. But we have learned from the waste management experience of previous generations that we must not dump waste without any protective measures whatsoever. There are contaminated sites in many countries that constitute an environmental threat, such as old waste dumps or industrial sites where contaminated wastes have been used as fill. It is we, the generations of today and tomorrow, who must face the task of rehabilitating these sites by adopting the necessary cleanup measures and paying for them.

To gain control over today's and tomorrow's wastes, the Swedish Government and the Swedish Riksdag, or parliament, have, like the governments and legislatures of many other countries, established goals for waste management, namely to:

- reduce the waste quantities
- reduce the danger posed by the wastes to health and the environment
- ensure proper disposal of generated wastes

In response to proposals in the Ecocycle Bill, the Swedish Riksdag has decided on guidelines for sustainable development within a number of different areas. The basic idea is that the state should specify goals and frames for the work, after which the producers should take responsibility for achieving these goals. The Ecocycle Bill also states that the flows and use of harmful chemicals should be reduced, flows that nevertheless contain harmful chemicals should be closed wherever possible, systematic risk management of chemicals needs to be further developed, use of the most harmful chemicals should be phased out, and plans for risk limitation should be drawn up for a number of substances within a five-year period.

Mercury is a very hazardous substance, harmful to both human health and the environment. Several years ago the Swedish Riksdag decided that the use of mercury for most purposes should eventually cease altogether. This year (1994), the Riksdag passed a motion that mercury use should be phased out, the target year being 2000. In the form of amalgam, mercury may not be used in the teeth of children and young people after 1 July 1995, and its use for adults should cease by no later than 1997. There are certain exemptions for mercury use, e.g. for the chlor-alkali industry.

Collection of discarded mercury-containing products and goods has been under way for many years in Sweden. These discarded products and goods are classified as hazardous waste and dealt with accordingly. A mercury phase-out means that it is firstly the input of new mercury to society that is reduced. Large quantities of mercury are still present in goods and products still in use. The collection rate varies for different types of products and will be improved through targeted measures.

Today Sweden lacks the capacity to dispose of its own mercury waste. Until recently, collected waste has been stored at SAKAB or exported for reprocessing and reuse, as in the case of amalgam.

The Swedish Environmental Protection Agency was instructed by the Government a few years ago to investigate how the collection of discarded mercury-containing products and goods could be improved, and how the waste should be disposed of. In the course of the investigation, which resulted in the report "Phasing-out our unseen mercury stock", the Swedish Environmental Protection Agency proposed that mercury-containing waste should not be reclaimed and reused since Sweden has decided not to use mercury in the long run. Instead other solutions should be sought. The Swedish Environmental Protection Agency believes that mercury-containing waste should be disposed of in such a manner that the mercury is isolated in such a form and way that leakage to the external environment is as little as possible, viewed in a very long time perspective.

As already mentioned, mercury is a very toxic metal. Mercury is also a volatile metal that readily vaporizes and can travel long distances in the atmosphere. Today we are faced with a situation in Sweden with generally elevated levels of mercury in the natural environment. The concentration of mercury in fish in more than 10,000 of our lakes is now higher than 1 mg/kg and the levels continue to rise. (It is a goal in Sweden that the mercury level in fish should not exceed 0.5 mg/kg if the fish is to be fit for human consumption.) The mercury load on our environment in large areas in Sweden is well above the acceptable level today. The Swedish Environmental Protection Agency therefore believes that very vigorous pollution control measures are required both in Sweden and in surrounding countries in order to improve the situation. This has led the Agency to conclude that one far-reaching pollution control measure for mercury waste is safe geological disposal, for example in a deep rock repository.

The Agency believes that capacity for disposal of mercury-containing waste should exist within the country, and that mercury waste should not be reprocessed for reuse. This also means that the Agency believes that exports of mercury waste for reprocessing and reuse abroad is not a feasible
alternative, at the same time as use of mercury in Sweden is deemed to be such a great threat that it shall cease, the target year being 2000. Exports of mercury waste are therefor no longer permitted.

The Swedish Government and Riksdag have considered the proposals submitted by the Swedish Environmental Protection Agency in its report, and the Government has decided to give the Agency an assignment that includes both an action programme for more efficient collection of used goods and products containing mercury and preparation of a proposal for final disposal in Sweden of mercury-containing waste. Achieving a long-term safe disposal of mercury may therefore entail that the waste has to be placed in an underground rock cavern. Experience from the field of radioactive waste disposal should be drawn upon in designing such a repository. The Swedish Environmental Protection Agency has received an appropriation of about SEK 2 million per year for three years to prepare the proposal for a final repository.

The prospects of realizing a final repository differ appreciably when a comparison is made between radioactive waste and mercury waste. Due to the general perception of the risk posed by nuclear power and radioactive waste, no one questions the highest possible level of ambition for disposal of radioactive waste. Mercury, which has long been used and which many of us still carry around in our teeth, does not pose as strong a perceived threat.

If we compare the time perspective for radioactive waste disposal (10,000 - 100,000 years) with that for hazardous waste, there is a great difference. When planning landfills, even landfills for hazardous waste, we speak today of a time horizon of 1,000 years in Sweden, in other words until the next ice age. This represents a great increase in the level of ambition in the past few years, so that today's landfills do not yet live up to these ambitions. The question is: what time perspective should we have for an underground repository for mercury waste? Should we choose 1,000 years or more? What is reasonable?

The next question is what level of ambition we should have for acceptable leakage levels. For mercury there is no established acceptable leakage level. Today there are many sources of emissions and deposition from the atmosphere. The most logical answer would be to set a level that nature can take. But our knowledge of what nature can take is incomplete, and here again the question is what time perspective should be applied in establishing effect levels or critical levels, since metals accumulate gradually in the environment. Is it possible that new future knowledge of effects will compel future generations to adopt measures anyway, and should we put in additional safety margins to allow for this?

Another question is: Is a deep rock repository the only conceivable alternative for achieving a given maximum acceptable leakage level? Are the risks greater for leakage with other alternatives, such as surface disposal? Could such a greater risk be accepted? Or is the relatively large concentrated quantity of mercury in a final repository and the risk it represents sufficient in itself to warrant an underground repository?

The advantage of disposal in deep crystalline rock is that the rock provides a stable mechanical system. The rock itself can be regarded as a very qualified cover layer with a powerful protective capacity. The rock provides sufficient protection against such processes as erosion, glaciation, land uplift, etc. In the case of surface disposal, similar processes can lead to a degraded protective effect of the cover layer and therefore alter the conditions presumed when the landfill was designed and assessed. Viewed in a longer time perspective, great difficulties can be assumed to exist in the case of surface disposal in counteracting various weathering processes, for example as a result of oxygen intrusion. Large uncertainty factors can be accepted for harmless materials deposited there, but for mercury-containing waste, where a more qualified disposal is required, a deep repository would offer a very large safety margin. Additional advantages with a deep rock repository, providing extra safety, include the stable chemical environment and the limited water flow, which means a lower
transport capacity for the mercury. In surface facilities, moreover, there is a greater risk of gaseous mercury emissions.

If we assume we can build a deep rock repository in Sweden, one important question remains, however. Who is to pay the extra cost for the higher level of ambition entailed by an underground repository? Funds have not been set aside in any reserve for the final disposal of mercury in Sweden, with the exception of for batteries. A retroactive producer responsibility would be difficult to impose, since many producers are no longer in business. And the national budget is already highly strained. Should the mercury use of the last few years therefore be burdened with costs that include the environmental costs for the mercury use of previous decades? A fundamental shortcoming has been, and still is, that the risks of environmental impact from goods and chemicals have not previously been taken into account, due to the fact that the negative environmental effects have not had any assigned cost and have therefore not been included, and are still not included, in the calculations of the producers and consumers.

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GENERAL DISCUSSION

Dr. Flowers

We will now have our discussion on the Session I papers. Of course, the subject is the background to current environmental policies and you have heard a lot about how the subject has been evolving from Bill Long. You have also heard two interesting studies on lead and mercury, for example. I invite comments and questions concerning the similarity or otherwise between these policies and trends and what we heard from Colin Allan this morning about the present position of radioactive waste disposal.

Dr. Dejonghe

I have a question for Dr. Morgenroth and Mr. Long might want to add something as well. When we make a risk assessment of a repository in the nuclear field, we are comfortable to have a reference value which is quite widely accepted. This is the ICRP value of a risk of $10^{-5}$ which in international regulations is reduced to $10^{-6}.y^{-1}$ or a value in between. We have this reference value, this standard, to declare that a situation is or is not acceptable. Is there a similar tendency in the area of chemical wastes? I do not know of any standards or references other than the LD50 values. There exist maybe more and I would appreciate having your comments.

If I could extend this question a little further, I did not hear any comments concerning the assessment of a repository and the rules and criteria imposed on repositories. In the nuclear field we make an assessment and extrapolate from this assessment long, perhaps too long, periods of time which have something to do with the half-life of most of the radioisotopes that we handle. I doubt whether the criteria applied to chemical wastes, and I am thinking essentially about mineral wastes, are compatible with a maximum acceptable risk value. If I am not wrong, in several of our countries, including my own, Belgium, the criteria for a dump site or a repository for non-radioactive hazardous wastes are of the type "thickness of a sheet of plastic, thickness of a sheet of copper, thickness of a clay layer", etc. The site must then be monitored for a period of thirty or fifty years and that monitoring must be extended if estimated as being necessary.

This may be a complex question I am asking, but I hope you have understood it and I would appreciate comments.

Dr. Flowers

I should invite Bill Long, if he wishes, to respond to that. Is there any analogy with the technical regulatory standards which the nuclear industry uses?

Mr. Long

I will let my colleague deal with that, but I will make one observation. Your description of the situation implies a difference between the level of sophistication and maybe consensus on the criterion approach to the storage of nuclear wastes and what exists in the non-nuclear area. The criteria differ from country to country and organisations, such as the World Health Organisation, which try to establish some guidelines, but they remain quite distinct. Victor Morgenroth will speak more specifically on that subject.
One of the things that is happening in the non-nuclear area involves transborder movement of hazardous waste. Over the past couple of years the OECD countries, the European Community and others have discussed how waste is to be moved across borders and under what conditions. One of those conditions is the understanding that in the country of import the waste will be dealt with according to environmentally acceptable conditions. This is, in theory at least, to be enforced. For the first time countries have started to get together and discuss standards and criteria. This has not, however, proceeded very far. One can go to the US Environmental Protection Agency and other agencies and find criteria for the thickness of plastic, etc.; yet non-nuclear waste management is not as uniform or as sophisticated as in the nuclear field.

In terms of specific chemicals and how they are dealt with, I prefer to have my colleague address that question.

Mr. Morgenroth

Unfortunately the question asked is far less complex than the answer when addressing the chemical field. In terms of reference values, like a $10^{-6}$ risk, they are rather complicated in the chemical field for a number of reasons. Often different types of effects - cancer, immune tox and other things - are treated differently. In general, the margin of safety or the extrapolation to an acceptable or safe dose is dependant upon the nature of the effect, and the type and the extensiveness of the data. In general, longer term data from animal studies are applied with factors of around 100. There are some new approaches and methods under development. The OECD and our division are at the heart of these developments in our effort to harmonize risk assessment and to develop what we call "good assessment practices." One way to improve the situation is that when carrying out assessments those involved should explain how the safety or extrapolation factors were derived.

There have been studies in the past on a limited number of substances that have suggested a factor of ten for both interhuman variability and for interspecies variability. That is where the 100 comes from. There are far more sophisticated approaches starting to be applied on individual chemicals. One of the banes of the scientific aspect is the $10^{-6}$ figure which floats around in the chemical field. What is normally quoted is the experience with the nuclear field in linearity at low dose. The chemical field is beginning to recognize that linearity of dose-response curves at low dose is probably not realist, even for carcinogens, because it is associated with mutational events, the same way radiation is associated with mutational events. People, however, have a tendency to forget about such things as the DNA repair mechanisms. As we become more sophisticated, we get equally more sophisticated models.

A number of countries apply the $10^{-6}$ criterion. The Netherlands, in particular, applies a rather interesting system associated with $10^{-6}$ in a number of their policies concerning, for example, land use planning and siting. You get one type of regulation with risks of $10^{-6}$, and you get another type of reaction in terms of assessment and in terms of regulatory response at $10^{-6}$ or higher. There is no single factor, like $10^{-5}$, within the nuclear industry. There is a movement towards harmonization, but I would say that in an attempt to be transparent, the movement is more in the direction of a mutual understanding of what each assessor does in an attempt to be transparent.

In response to the second question about repositories, there are criteria associated with landfills or sites that are designated for hazardous materials versus sites for general municipal waste. Most of those criteria are based on studies of leaching through the barrier systems. A number of criteria have been established, but they are based only on relatively short experimental time frames and most of the criteria are certainly not associated with geological time frames. Longer time scales are, however, one of the present trends. Disposal is now being seen in terms of eternity rather than in terms of one or two generations.
Mr. Bernero

I would like to supplement what Victor Morgenroth just said. It is important to note that when we who are involved with nuclear technology speak of $10^{-5}$ or $10^{-6}$, we usually mean the probability per annum of latent cancer fatality. In the U.S. legislation associated with non-nuclear or general waste, the coefficient of $10^{-6}$ is growing more and more predominant and it is $10^{-6}$ occurrence of cancer in a lifetime. It is approximately two orders of magnitude different. As we speak here today our Congress is in recess, but they are considering a statute to renew what is called "CERCLA", and I can never remember what it stands for, but it is the waste management law which has superfunds. They intend to include in the renewal of that law $10^{-6}$ lifetime risk of cancer occurrence as the clean-up criterion for radioactive material. That will give us a truly absurd value for radioactive material cleaning. This is strongly controversial in the U.S. right now.

Mr. Lefèvre

Ceci est plus un commentaire qu'une question aux orateurs. Je voudrais d'abord dire ma satisfaction concernant cette participation importante de personnalités de l'environnement et de problèmes de pollution non radioactives. En particulier, les paroles introductives de M. Morgenroth m'ont fait beaucoup plaisir. J'ai co-présidé une réunion de ce genre il y a quelques années qui n'avait pas, semble-t-il, eu le même écho du côté des environnementalistes. Nous avons intérêt à nous attacher aux points communs plutôt qu'aux divergences entre nos problèmes, entre les déchets non nucléaires et les déchets nucléaires. On connaît tous les aspects spécifiques du domaine nucléaire, des problèmes du radioactif et la perception très négative du public.

Ma remarque est moins technique que celle de M. Dejonghe. Elle porte plus sur cet aspect de comportement et d'approche du problème, surtout vis-à-vis du public. J'ai été frappé par les événements que tout le monde peut connaître, par la similitude de la réaction du public devant les problèmes des déchets dangereux, hautement toxiques comme on dit, qu'ils soient nucléaires ou non nucléaires. En France, en particulier, nous avons eu il y quelque temps des articles de journaux ou de télévision très violents sur les échanges de déchets toxiques entre la France et l'Allemagne. Je dis bien "échanges" parce que cela se fait dans les deux sens. Je ne suis pas là pour accuser un pays ou l'autre, cela se pratique. Il y a des déchets hautement toxiques français qui s'en vont en Allemagne, dans les mines de sel, et puis il y a également des déchets allemands qui viennent en France, en Alsace, dans certaines mines de sel également. Ce sont des pratiques qui ont scandalisé le public. Il y a l'aspect commercial mais aussi la découverte de certaines opérations industrielles qui n'étaient pas connues du grand public et qui ont provoqué des réactions tout à fait violentes pour le domaine nucléaire.

L'approche que nous devons avoir en tant que responsables de gestion de déchets est très voisine. Kristina von Rein a dit qu'en Suède les décisions de l'Ecomcycle Bill conduisaient à des règles très générales, très voisines de celles que nous connaissons pour le nucléaire. Mais elle a également ajouté que pour les déchets de mercure la tendance (je ne sais pas si c'était une décision) était d'arrêter l'utilisation du mercure pour ne plus avoir de déchets de mercure au-delà de l'an 2000. On peut comparer cette décision suédoise à la même décision suédoise concernant le nucléaire : il y a un problème grave, on arrête. C'est une décision sans nuance. Je ne dis pas qu'elle sera définitive mais enfin elle a le même sens. Je crois qu'on ne peut pas attendre de la part du public de réactions nuancées sur ces problèmes de risque important ou considéré comme important. On voit que ce sont des réactions de refus qui viennent tout de suite.

On a le problème, dans un autre ordre d'idée, des composés fluorés, des bombes à aérosols avec la couche d'ozone, et on a vu la nécessité d'arrêter d'utiliser ces composés. C'est une tendance naturelle du public de dire qu'il faut arrêter puisque c'est dangereux. On connaît cela dans le nucléaire. Beaucoup de pays ont été confrontés à cet aspect lié aux problèmes des déchets radioactifs ou autre
type d'incident possible. Il y a, je crois, beaucoup de points communs dans les approches et je crois que le dialogue peut être très intéressant à poursuivre entre les responsables pour les déchets hautement toxiques non nucléaires et les déchets radioactifs.

Je terminerai en disant que nous avons à naviguer entre deux écueils qui sont opposés dans ce domaine de la perception du public. Le premier c'est le secret. On reconnaît, parce qu'on a commencé un peu dans cette voie dans le nucléaire, qu'il est très dangereux de vouloir pratiquer une politique du secret. Un secret n'est pas éternel, dès qu'il est dévoilé le scandale est très important. Donc, on ne doit pas faire de secret. A l'inverse, je dirais qu'on ne doit pas faire de publicité. D'une manière générale, c'est aussi dangereux de faire trop de publicité sur ce que l'on fait dans le domaine des déchets parce que, comme je le rappelais, les réactions du public sont sans nuances et vont à l'excès, vers des positions de refus complet, ce qui n'est pas forcément raisonnable. Donc on doit naviguer entre ces deux écueils et je pense qu'on doit trouver la bonne voie au fil d'un certain nombre d'exemples pratiques, connus aussi bien dans le domaine non nucléaire que dans le domaine nucléaire.

(This is more of a comment than a question to the speakers. First, I would like to express my satisfaction concerning the participation of numerous personalities from the environment and non-radioactive pollution sectors. In particular, I was very pleased with Mr. Morgenroth's introductory remarks. I was co-chairman of a similar meeting that took place several years ago which did not, it seems, receive the same echo from the environmentalists. It is important that we concentrate on points we have in common rather than on our divergences between nuclear and non-nuclear wastes. We are all familiar with the aspects specific to the nuclear field, of the radioactive problems and the very negative public perception.

My remark is less technical than Mr. Dejonghe's. It deals more with the behavioural aspect and how we approach this problem, particularly vis-à-vis the public. I am struck by the similarity of the public's reaction to the events everyone is aware of; when it was confronted with the problems of dangerous, or "highly toxic", wastes whether they were nuclear or non-nuclear. In particular, we recently had in France a series of violent newspaper and television reports on the exchanges of toxic waste between this country and Germany. I say "exchanges" because this clearly indicates that it works in both directions. I am not here to accuse one or the other country, but to note that such a practice exists. There are highly toxic French wastes being sent to Germany, to salt mines, just as there are German wastes arriving in France, in Alsace, also to certain salt mines. Such exchanges have scandalised the public. The violent anti-nuclear reactions were provoked not only by the commercial aspect of these operations, but also by discovery of certain industrial operations that were until then unknown to the public.

We, as those responsible for the management of wastes, must take a similar approach. Kristina von Rein stated that in Sweden the Ecoycle Bill produced very general rules similar to those we have in the nuclear domain. But she also added that the tendency for the treatment of mercury was (I am not sure that this has been formally decided) to stop the utilization of mercury so as to have no further mercury wastes after the year 2000. One can compare this decision with the Swedish decision on nuclear wastes: there is a serious problem, so we stop. It is a decision which does not allow for any subtleties. I am not saying that it is a final decision, but in the end it means the same thing. I do not think that we can expect from the public a subtle understanding of problems related to serious risks or which are considered as being serious. There is an outright refusal on their part to even consider the problem.
We also have the problem of fluorine compounds, aerosols, affecting the ozone layer and we perceived the necessity to stop all use of these materials. It is a natural tendency of the public to declare that we must stop because it is dangerous. We are familiar with this attitude in the nuclear domain. Many countries have been confronted with problems tied to radioactive wastes or other types of possible accidents and there are, I think, many common points in the approaches taken. I think an interesting dialogue can be undertaken between those responsible for highly toxic non-nuclear wastes and radioactive wastes.

I would end, finally, by saying that in order to deal properly with public perception, we must navigate between two opposing stumbling blocks. The first is secrecy. We know, because in the nuclear domain we began on this path, that it is very dangerous to practice a policy of secrecy. No secret is eternal; when it is revealed, the scandal is enormous. So we must not work in secrecy. On the other hand, we must not publicise our work. In general, it is just as dangerous to make too much publicity on nuclear wastes because, as I have already said, public reaction lacks all subtlety, it is excessive and tends to refuse any consideration of this problem, which is not necessarily reasonable. Thus, we must navigate between these two stumbling blocks and I feel that the right path can be found only after results have been obtained from a certain number of practical examples known to both the nuclear and non-nuclear domain.)

Mr. Long

I would like to make two observations on this because public perception and attitudes are at the heart of the issue. One of the trends in environmental management is expanding information availability in the form of, for example, "public's right to know" and community awareness programmes; and pressing industry to carry out audits, letting the communities know what wastes are being generated and what is happening with them. The countries that have had experience with this kind of management, although it can be a difficult one, have over the long run found that it is a plus for them.

Secondly, I would like to come back to this matter of countries or the public expecting too much. The example used was the stratospheric ozone. Without arguing this, I think what we see in the environmental field in terms of public perception is that, in democratic societies, smart people working in the technology field can find a way to solve problems. Chlorofluorocarbons and aerosols, which I dealt with before coming to the OECD, are a perfect example. Industry's first reaction to public concern was that it was impossible to get rid of these products, that it would cost them $6 billion and, consequently, put them out of business. A year later, after having researched the problem, they came back and said maybe it would cost them $3 billion. Two years later not only can they get rid of it, but money can be made on substitutes. A lot of people think that if industry is pushed hard enough, they will find a way to do it. There is a widespread attitude that through technology and people working together, someone is going to find a way to deal with the problem. The public is willing to set up these kinds of challenges and see how far they can push government and industry to reach the goal they have set. In our area, this is leading to pressures for fully closed manufacturing cycles and no emissions. This is perhaps idealistic, but I think it is part of the mentality and the challenge that you folks will be faced with.

Dr. Ahearne

I would like to ask Bill Long about his description of the history of environmental movements. Would you care to comment on the shifting perceptions as to the hazards of, for example, PCB, Dioxin, ALARA, and so forth? I see similarities between issues on knowledge and hazards as similar to those on knowledge about radiation hazards.

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Mr. Long

I will make just one observation and then perhaps Victor Morgenroth can get into the matter of chemicals because I am not an expert in this field. My comment is on the different perceptions of risks, and once again I draw on my experiences in the U.S. Environmental Protection Agency. A former EPA Administrator would constantly complain that what he was hearing from his science advisors in terms of priorities did not match what he heard from the public. This goes back to the public's concern about anything suggesting there is a threat of cancer; a concern which always gets high priority. The science advisors, however, were saying that for environmental management you have to deal with some of the longer term concerns related to the sustainability of biological systems: that they are important threats to global processes and it is important to get some of the focus and resources on this and away from worrying about cancer from chemicals and which is expressed at almost ridiculously low levels. That is a general comment: the advice is to put more resources into the longer term global issues and the biological support systems, the wetlands, and agricultural lands as opposed to some of the chemical concerns.

Mr. Morgenroth

The same problem exists in the chemical field. If you ask groups working on chemical safety, they will give a completely different priority list as compared to the public. A lot of that is due to bad communication. In the United States and other countries cancer gets a very high priority in the public view whereas most scientists in the field are much more concerned about issues such as effects of the immune system and the effects of chemicals in terms of suppression of the immune system or reproduction. As the methods and the approaches get better, the public does shift in its perspective of where the risks are.

One good example is the food industry. It is clear to most people working on food safety that issues of natural toxins or bacterial contamination are far more serious than the safety of food additives. The few chemicals that are added to food have normally undergone extensive testing, yet when you get a situation like ALARA, already referred to, it is very hard to influence the public. This is probably due to poor communication of risk by the agencies and industries involved to make known that this is not as serious a situation as some of the other materials that routinely contaminate foodstuffs or the natural products.

Today, this is a very difficult area for the new genetically engineered materials. In fact, one of the issues will be that in the food itself there are toxins. One of the most difficult things that food safety officials have faced was the discovery that some of the components of black pepper were highly carcinogenic. The public will not allow you to ban black pepper. On the other hand, you have to take action against a number of other products that may have had these same chemicals intentionally added to them. It is not necessarily consistent. Activity doesn't always reflect perception and true assessments are not always reflected in the perception that is fed back. As a consequence, there will continue to be major problems until people become more transparent and explain exactly what goes on in the assessment.

Dr. McComtie

This is a question about setting priorities in risk areas. Bill Long quoted someone from EPA who agonized over the conflicting priority list of the public with that of the technical experts. We have the same problem all the time in the radiation field where we have our own set of "objective" priorities, but we see and we hear all the time that we should listen to the public's concerns. We end up in a dilemma. We have only two ways to progress. Either we listen to the public and we weigh the irrational fears they have and take them fully into account or, what we tend to do as technologically-based people, is hope that by educating the public it will somehow be different. How do you perceive
such problems in the chemical field? How does the Environmental Directorate, for example, see its role? Is it primarily trying to assess what people think is risky or does it see its role as being more objective?

Mr. Long

Let me try to deal with this question of how we see our role. In the Environment Directorate, and in the OECD Secretariat as a whole, we carry out certain functions. First, we provide a forum for people like yourself to come together to share experiences. Secondly, we analyze issues to see if we can get agreement, and try to understand what the really important issues are. We then try to go further and see if we can find a meeting of the minds on the issues considered as more important, to seek a consensus on their solutions, and we convert these into guidelines or counsel that carry some weight. One of our most important roles is to try to see where the consensus might be among the countries. In a case such as this conference, we would hope that we could provide a service within the framework of the OECD to find agreement and document it so that governments and ministries - when they have to explain to the public their preference for going the deep geological route - can point out that they are not alone in arguing this position. They can say, "not only do we see it this way, but we now have twenty-five countries that lean the same way". It is interesting to draw a parallel with economic problems: everybody blames the prime minister or president of a country, and you swear your country is the only one confronting such problems, while in fact many people in many different countries are faced with these same problems. There are a lot of advantages in trying to find a meeting of the minds by pointing out that there is a collective point of view on the issue and that everybody who has worked on it is coming to the same conclusion. That will certainly strengthen the hands of the Member countries. Otherwise you are out there alone and someone is always pointing out that your neighbour does not follow the route so why should he believe that your opinion is better than the others. In general, that is how we perceive our role and that is why we think it is useful to have these meetings and try to get a collective opinion.

I think there was also a question about chemicals that Victor Morgenroth possibly wants to address.

Mr. Morgenroth

Rather than try to answer the question specifically, I will give an example of something that is ongoing in one of the key priority activities. As early as 1972, at the first Stockholm Conference, there was an effort to look at chemicals. As a result of that meeting a list of priority substances of over 270 chemicals was published and which outlined the actions, etc., to be taken. Until about 1987 those 270 chemicals received a lot of attention. Even today we are still working on lead, cadmium, and mercury in particular. It is interesting to note that there has been some impact on mercury over the years and it is likely that in the near future there will be more work to phase out the use of this product, probably by the end of the century. At the same time, most scientists and people working in the field realized that the greater problem, as a National Academy of Science study in the United States showed in 1984, was that out of the industrial chemicals in use, about 2000 represented 95% of the volume of all chemicals used. Of those two thousand chemicals, only about 3% had data other than LD50 values so that no one had any idea of what the potential reproductive or carcinogenic effects of those chemicals were. It was extremely difficult for governments or industry to devote resources for the testing of those materials because of the economic costs. Without data it is hard to suggest that there might be something wrong. On the other hand, all the time and energy were being spent on the 35 or 40 chemicals out of the 270 that originally appeared on that list.

In 1987 the governments of OECD recognized that the only way to deal with this was to work together. As a result, they started a programme of establishing national inventories of chemicals in use, to look at those with high volume and examine the data that was available for them. This lead
to the publication of the OECD Representative List of High Production Volume Chemicals. There is a co-operative testing programme of those chemicals and to date over 95 of them have now been tested. Three of the 95 were considered to be of concern and have been flagged for government and industry action. The programme is entirely voluntary; industry pays the costs of testing each chemical from a set of data determined as a critical set of information for screening those chemicals with potentially serious consequences. There are about 17 governments who participate in this programme and they actually assess those chemicals together. The United Nations has agreed to take those assessments and transfer them globally. The OECD can, in a sense, play a role of trying to get people consider real priorities by simply having governments work together. This is an important and critical aspect of our role.

Dr. Allan

I wanted to ask for a comment from either Bob Bernero or Mr. Morgenroth on a couple of impressions I have. One is that when we are dealing with the difference of a factor of 100 between the chemical criteria and a radioactive criterion, this factor of 100 represents in some measure the uncertainty in extrapolating from animal models to human models.

I also wanted to have some feedback on the distinction between what I would call naturally occurring hazardous materials - mercury, arsenic, lead - and organic hazardous materials. The standards that are applied are different in the two cases. In the first case, I have the impression that the standard is based more on comparisons with naturally occurring levels, in the case of mercury for example. In the case of organics, the drive is to almost zero tolerance, but certainly this is when you get into these factors of 100 and lifetime risks of $10^{-6}$. I would ask the speakers to comment.

Mr. Bernero

I think Colin Allan is right. The difference of roughly a factor of 100 is in large measure due to uncertainty with chemical pollutants. The data are just much more sparse and difficult to obtain, but it is extrapolation of animal data whereas radiation toxicity has been established by the unfortunate experience of World War Two.

Mr. Morgenroth

I can agree with that. In fact, most of the chemical extrapolation techniques at low dose are based on the radiation model. The problem with the chemical extrapolation is not only do you have a high to low dose extrapolation, but you also have to extrapolate from an animal to humans. So because of those two kinds of things there is a perception of the need for increased margins of safety. In part, it is lifetime risks versus non-lifetime risks because the data is not there.

To answer your second question about natural substances versus organic substances, I do not think your perception is correct. The difference is that with most naturally occurring materials, and it is analogous to nuclear materials, there is much more experience with human toxicity, and so because of the information available on human toxicity, for example with lead, the perception of safe levels often involve direct comparison with no margin of safety. You perceive that at three microgrammes per decilitre of blood, since no effects have yet been detected, it might be an acceptable level. There is no application of hundred fold or thousand fold safety factor.

There is much less data for organics. Most of the time it is, in fact, animal data and therefore more stringent standards are applied and associated with varying degrees of margins of safety. I know of a number of organics that have human experience and as that human experience increases, either through metabolism or unfortunate incidences of toxicity, the margins of safety change. Margins of safety will often be as low as five or as high as 80-90 thousand because of the human data. Dioxin
is a perfect example of this. It is far more toxic to humans in certain types of situations, in certain types of toxicity than animal species. However, for cancer, dioxin seems to be far more potent towards animal species than it is to human species. So it is a much more complex issue.
SESSION II

ETHICS AND THE ENVIRONMENT
Ethical Principles and the Environment in a Democratic Society

John F. Ahearne
Executive Director
Sigma Xi, The Scientific Research Society
and
Adjunct Scholar, Resources for the Future

Introduction

In the United States, the responsibility for handling the high-level nuclear waste resides with the federal government, whose agent is the U.S. Department of Energy. To carry out this obligation involves three federal agencies. The Department of Energy has a responsibility of selecting a site for a repository, characterizing that site, getting a license, constructing, and operating the repository. The Environmental Protection Agency has the responsibility for establishing the basic standards which the site must meet. These standards are to be focused on protection of individuals outside the site. The U.S. Nuclear Regulatory Commission (NRC), which has the responsibility for overseeing the construction and operation of the repository, and, if the regulations are satisfied, will issue a license to the Energy Department for the repository, must develop NRC regulations to implement the EPA's regulations.

There are four key points in this process:

1. Locating a site;
2. Characterizing the site;
3. Developing EPA regulations; and
4. Licensing the site.

In the United States, as well as in other countries, these steps have become very controversial. Attempting to implement them has led to major public confrontations with government in several countries.

In the United States, and in some other countries, there are actually two problems of high-level waste. The spent fuel, commercial, or "civilian" high-level waste, and the military high-level waste, coming from the manufacture of nuclear weapons. In this paper I am in principle addressing both, although I will refer only to the commercial waste. However, the fundamental characteristics of the waste from the military operations are not different, although their current conditions can be quite different.

Most of the Energy Department's reactor waste consists of material from the production of nuclear weapons: 84% from production reactors, 15% from commercial reactors, 1% from research reactors, and less than 1% from naval reactors. The percentages are a total inventory when

The United States government has struggled for nearly four decades with the problems of disposal of high-level wastes. Historians will find many "new starts". For example, in 1980, President Jimmy Carter sent a message to the Congress on waste management in which he stated: "...past governmental efforts to manage radioactive waste have not been technically adequate. Moreover, they have failed to involve successfully the States, local governments, and the public in policy or program decisions." He ended by stating that this policy was intended to "build public confidence in the ability of the government to do what is required in this area to protect the health and safety of our citizens." (Message from the President of the United States, transmitting a report on his proposals for a comprehensive radioactive waste management program, February 12, 1980.)

It failed.

History

In the United States the official government position for the permanent solution of high-level waste has been to place it in a geologic repository. This position, developed by the Atomic Energy Commission, a predecessor to the current Department of Energy, was endorsed by the nuclear utility industry and has been the official United States policy from the late 1950's. Of course, for the first 20 years there also was the assumption that the waste would be from the reprocessing of spent nuclear fuel. Studies by the National Academy of Sciences supported this position. Periodically, some objections would be raised, primarily concerning whether there was enough scientific knowledge to speak with certainty about the performance of such a repository.

The Atomic Energy Commission in 1956 put in place regulations that "in effect would require all high-level wastes to be permanently isolated from the environment." ("Federal Policy for the Disposal of Highly Radioactive Wastes From Commercial Nuclear Power Plants: An Historical Analysis", Richard G. Hewlett, Chief Historian, U.S. Department of Energy, 9 March 1978, p. 6.) The Commission was thinking both of the military wastes, because by that time, they had "millions of gallons of high-level waste stored at Hanford", as well as "the high-level materials that would be produced in nuclear power reactors." This concern led the AEC to ask the National Academy of Sciences to study the feasibility of disposing of waste in geological formations.

In 1957, the National Academy of Sciences, "recommended solidifying the high-level waste and disposing of it in salt mines or repositories." ("Nuclear Waste Policy and Politics", Luther J. Carter, Forum for Applied Research and Public Policy, Fall 1989, p. 6, referring to "The Disposal of Radioactive Waste on Land", Report of the Committee on Waste Disposal of the Division of Earth Sciences, NAS-NRC Pub. 519, Washington, D.C., 1957.) Consequently, "...by the end of 1970 the AEC had committed itself on...a policy for ultimate disposal of radioactive waste: (1) fuel elements from civilian power reactors would be processed by commercial plants and the high-level waste would be solidified in a form acceptable to AEC for shipment to a federal repository; (2) AEC would build a federal repository using a bedded salt formation for permanent, irretrievable storage of these wastes..." (Hewlett p. 15).

In the United States, site selection took more than 20 years, and may have to begin again. The Atomic Energy Commission initially selected as a demonstration facility a salt dome in Lyons, Kansas, based on the belief that salt would be the best medium for a repository. This position was based on (1) that water had not been present for hundreds of thousands years, as evidenced by the existence of large salt deposits, and (2) that the creep of salt under the heat of the waste material would lead to good containment, as the salt closed around the material.

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Lyons turned out to be a poor choice and, under much public criticism, the AEC abandoned the site. A historian has called it "The Lyons Debacle" (Hewlett, p. 17). It was about this time that political changes in the United States, first a decision by President Ford and then carrying out election promises by President Carter, led to the United States official position being that there should be what is called the direct cycle for the fuel cycle, which eliminates reprocessing and ends with disposal of spent fuel directly into a repository. This decision, reiterated by the current Administration, is related to proliferation concerns and has been strongly opposed by the U.S. nuclear industry for its claimed significant impact on potential future sales of nuclear power, both in the United States and abroad. The decision has little to do with high-level waste disposal and I do not intend to discuss the issues surrounding reprocessing.

In a letter report to the Nuclear Regulatory Commission, in 1978, the National Academy of Sciences supported the use of a deep-geological repository, but said "unreprocessed spent fuel elements should not be placed in a non-retrievable repository for radioactive waste." (Section 4.1, "The Geological Criteria For Suitable Sites of High-Level Radioactive Waste Repositories", August 3, 1978, Panel on Geological Site Criteria, National Academy of Sciences, Washington, D.C., 1978.) The Academy based this position on not creating a potential future source for valuable material, which could lead to repository intrusion.

The 1982 Nuclear Waste Policy Act established procedures to select sites for high-level waste repositories. The search for a site became a major political controversy, not only in the potential selected site areas. After a panel of the National Academy of Sciences validated the criteria by which the Energy Department would select a site, the Energy Department identified four possible sites, all in Western States. Three sites immediately led to strong protests, one for its closeness to the Columbia River, another for its closeness to the Ogallala aquifer, and the third, for its closeness to a national park. Thus, although there were four sites being characterized, only one, initially, seemed to have caused significantly less objection, a site near the nuclear test site in Nevada. The nuclear test site had been the location of more than 100 underground nuclear tests by the United States over a period dating back to the 1950's. At the same time, there was a provision in law that the DOE also should be searching for an eastern site, along with a western site. This provision reflected the need for a second site, because of a 70,000 metric ton constraint on the first site, but also it made selecting a western site more palatable, politically. There are many more nuclear reactors generating spent fuel in the eastern U.S. than there are in the west.

After several years of slow, if any, progress towards selecting a site, Senator Johnston became frustrated and introduced legislation that would select the Nevada test site and do away with any analysis of comparison to the other three. This was passed in 1987. To some, this was fitting, because Nevada, in much of the United States, is seen as the home of the major gambling city, Las Vegas, and the reaction of some in the U.S. was that Nevada had participated in a lottery and had lost.

This action did not resolve the controversy, since the people of Nevada and, in particular, the senior elected officials, senators and governor, were not in favor of this selection and were able to use the highly faulty selection process to generate considerable opposition in Nevada to the selection of Nevada for the high-level waste repository.

At the same time, the U.S. Environmental Protection Agency (EPA) very slowly developed regulations that a repository must meet. EPA's regulations were criticized by its own Scientific Advisory Board, by the National Academy of Sciences' Board on Radioactive Waste Management, and by a U.S. Federal Court. Some of these criticisms also laid out broad views of what should be included and what are the responsibilities of the technical community.

In 1988, the Board on Radioactive Waste Management, a permanent branch of the United States National Academy of Sciences, met to review the Environmental Protection Agency's approach
to developing regulations for high-level waste repository. The Board was extremely critical: "The United States appears to be the only country to have taken the approach of writing detailed regulations before all of the data are in. As a result, the U.S. program is bound by requirements that may be impossible to meet." ("Rethinking High-Level Radioactive Waste Disposal, A Position Statement of the Board on Radioactive Waste Management", National Academy Press, Washington, D.C., July 1990, p. vii.) "The Board believes this use of geological information and analytic tools -- to pretend to be able to make very accurate predictions of long-term site behavior -- is scientifically unsound." (p. 5).

"The primary goal of the program is to provide safe disposal; a secondary goal is provide it without any gross unfairness. As a result, the mechanisms of negotiation, persuasion, and compensation are fundamental parts of any program to manage and dispose of radioactive waste -- not mere procedural hoops through which program managers must jump. The second ethical point is also important: the demand for accountability in our political system has fostered a tendency to promise to a degree of certainty that cannot be realized." (p. 6).

"Science and engineering are part of broader human activities, and as science enters the public arena, decisions can no longer be purely scientific; good science is not enough. Science has also become an important source of information and analysis for the public policy process, and scientists find themselves being called to account for, and to justify the results of, those decisions...Scientists have been sheltered...in the past, but the increasing scale, sophistication, and pervasiveness of technical information require a corresponding increase in the sophistication with which these value judgments are made." (p. 18).

EPA's criteria also were criticized by the Nuclear Waste Technical Review Board set up by the Congress to review the high-level waste program:

"...the release limits [in the draft revision of 40 CFR 191, the EPA high-level waste regulation] appear very conservative and inconsistent with present day regulatory practice and scientific consensus." (Nuclear Waste Technical Review Board, First Report to the U.S. Congress and the Secretary of Energy, March 1990, p. 31.)

In addition, the criteria have been criticized by EPA's own Scientific Advisory Board:


In 1987, the federal court remanded part of the EPA standard, effectively halting any NRC licensing process, because the NRC regulations had to be based upon the now remanded EPA regulations.

Senator Johnston, once again frustrated by the slow approach of EPA, successfully put into law a provision that the standards should be set based on a study of the National Academy of Sciences. In particular, the law asked the National Academy to answer three questions (Section 801, Energy Policy Act of 1992):
1. "Whether a health-based standard based upon doses to individual members of the public from releases to the accessible environment...will provide a reasonable standard for the protection of the health and safety of the general public".

2. "Whether it is reasonable to assume that a system for post-closure oversight of the repository can be developed, based upon active institutional controls, that will prevent an unreasonable risk of breaching the repository's engineered barriers or increasing the exposure of individual members of the public to radiation beyond allowable limits".

3. "Whether it is possible to make scientifically supportable predictions of the probability that a repository's engineered or geologic barriers will be breached as a result of human intrusion over a period of 10,000 years".

In the United States, spent fuel was stored at reactor swimming pools. The basic initial concept was that after 10 years this would have been transferred to a reprocessing facility. Once it was clear that reprocessing was not going to be done in the United States, extending life at the fuel pools was selected. Many utilities then reracked the spent fuel pools to increase their capacity. When the capacity began filling up even with the reracking, some large utilities with more than one plant shifted spent fuel from an older plant to a newer plant that had more pool capacity. In the absence of any off-site storage, other utilities have used dry-cask storage. This is sometimes called Independent Spent Fuel Storage Installation (ISFSI). At the end of 1993, five on-site dry-cask storage facilities had licenses from the NRC: Surrey (Virginia Power), Robinson-2 (CP&L), Oconee (Duke), Fort St. Vrain, a closed plant in Colorado, and Calvert Cliffs (Baltimore Gas and Electric). Another plant, Palisades (Consumers Power) is using dry-cask storage under a general license. The first of these facilities was the Virginia Power facility that began in 1986. (Nuclear News, December 1993, p. 35, "On-site Dry Spent Fuel Storage: Becoming More of a Reality", Betsy Tompkins.)

A study done for decommissioning a United States reactor indicates that significant funding can be saved by using dry rather than wet spent fuel storage. For this particular plant, the Rancho Seco PWR, a total of 493 fuel assemblies had to be stored. Dry storage is estimated to save $7.5 million annually over wet storage, with the primary savings being in utilities staff. ("Spent Fuel Storage: A Decommissioning Perspective", Rita W. Bowser, Dan R. Keuter, N. R. Miller, Journal of Nuclear Materials Management, May 1991, pp. 13-16.)

Different Views

There have been many environmental objections surrounding nuclear waste disposal in the United States. Sometimes it is difficult to tell whether these are related to concerns about the hazard or to opposition to nuclear power. The latter opposition can be based on concern about safety, concern that the environment cannot be protected from nuclear waste, or that nuclear power is inherently linked to proliferation, which must be halted and reversed.

For at least two decades, the United States has been caught in a dilemma regarding nuclear waste. The two horns are positions taken by the technical community and by the environmental community. When I speak of positions of a community, the technical community or the environmental community, I do not mean to imply that every member of that community takes the position that I will attribute to the community. Rather, it is what I perceive to be the dominant view of members in that community, recognizing that, as with most distributions, there are tails on both sides of the peak.

The technical community supports the use of nuclear power. This community believes that nuclear power has proven advantages over fossil fuels relating to atmospheric pollution. The technical
community also believes that the disposal of nuclear waste is a solvable problem, which has been solved, and that geologic repositories are not the hazard which the environmental community describes them to be.

One articulate nuclear proponent has concluded a repository would pose little harm, although he recognizes the public disagrees:

"There have been other scientific analyses of the high-level radioactive waste hazards using very different approaches that I believe to be less valid than mine, but they come out with rather similar results. They also find the health effects to be trivial...Nevertheless, there can be no question but that the fear abounds...Probably the best evidence for this fear is that our government is willing to spend huge sums of money on the problem. The fear is surely there. Perhaps the most important reason for it is that disposal of high-level waste is often referred to as an 'unsolved problem.'" (Bernard L. Cohen, "The Nuclear Energy Option", Plenum Press, 1990, p. 199.)

On the other side, the environmental community believes that nuclear power is not worth the risk. Environmentalists perceive that other sources of energy are eventually less environmentally damaging than nuclear power. The damage they see from nuclear power is a combination of that from accidents, to which they characteristically ascribe a higher probability and greater consequence than does the nuclear community, and to the lack of a convincing solution to handling the nuclear waste. This latter position was the underlying rationale for the State of California in the mid-1970's passing a law which banned the construction of any new nuclear power plants until the government had demonstrated that a current solution to high-level waste disposal could be developed. Given that, in the United States, radiation protection regulations are reserved by law to the federal government, this California position led to lengthy arguments in the courts. In the end, the lower courts upheld California's right to pass the law, and the Supreme Court chose not to review the case, accepting the argument that this was not a radiation protection law, but rather an economic law, in which the State of California was merely concerned about the economic burden imposed on the ratepayers, if there were not any demonstrated solution to the waste to be generated by the California utilities.

One ironic aspect of this environmental debate is that the pro-nuclear groups argued that the nuclear waste must be taken off the surface, where it is a greater hazard to individuals, and placed deep underground. Thus, the environmental community, arguing not to use a repository, is ironically in a position of supporting keeping the hazard in a position of potentially greater exposure and the technology community is advocating placing it in position of less exposure. Of course, underlying the environmental community's position is a mistrust and disbelief of those organizations, such as the Energy Department, that are advocating the underground repository.

This mistrust stems from the governmental policies of the past, which have been simply described as "decide, announce, and defend."

The principles that are supposed to be applied in a democratic society are that a potential decision should be announced well before the decision is to be made, with all the necessary data and analyses made available to any concerned citizen. After a reasonable length of time, meetings should be held between the concerned public and the government officials and their staffs to discuss the ramifications of the potential decision, to discuss what new information is needed, and to discuss any other issues relating to the potential decision.

This has seldom been done, particularly with nuclear waste decisions.

The technical community has tended in the past to take the position that their technical analyses should suffice for the potential impacted area. However, the technical community has taken its responsibilities seriously. The boundaries of the repository have been examined extensively. A problem that the environmental community sees is that the time scale of consideration is not the time
scale of consideration in such related items as a nuclear power plant's operation. In a repository, there is not much doubt that a canister can be designed to contain the waste for hundreds of years and that a geologic site can be found to keep the waste from the accessible biosphere for an additional several hundred years after the canisters have failed. Thus, at a minimum, combining these two, technologists are quite confident that 1,000 year protection against the accessible environment is quite feasible. Longer times, even of an order of magnitude, are also quite possible.

However, the radioactivity will remain much longer than that, which means that the calculations will have to be carried out for that time frame, adding significant calculational uncertainty, as well as individual concern.

In addition to the nuclear community, the environmental community also has urged that action be taken, although not necessarily the same actions as the nuclear community suggests.

Matthew L. Wald, in the New York Times, quoted an environmentalist: "It is almost philosophical...we simply can't rely on distant generations to have the same sort of institutional controls over this very dangerous material that the current society does. We need to isolate this from the environment to the greatest extent possible, so we don't have to rely on distant generations to make sure that it's kept safely." ("Finding a Burial Place for Nuclear Waste Grows More Difficult", Science Times, 5 December 1989.) The speaker was Dan Reicher, then a lawyer at the National Resources Defense Council, who had won the case against the EPA's original standards and who is now Deputy Chief of Staff of the Department of Energy. (Quoted by Luther Carter op cit., p. 7.) Speaking in opposition to the AEC proposal of the early 1970's to build a retrievable surface storage facility, Gus Speth, now the Director of the U.N. Environmental Program and at that time another lawyer for NRDC, said "The big problem was, and is, that it implies long-term decoupling of waste from reactors. That is, we could have countless reactors without any assured means of permanent disposal." (Wald).

The nuclear power community is pushing for a repository. Some in the environmental community are thinking of other options:

"To leave a legacy that does not merely impoverish future life but may endanger it for millennia to come, constitutes an act of unprecedented irresponsibility." ("Nuclear Waste: The Problem That Won't Go Away", Nicholas Lenssen, World Watch Paper 106, December 1991, p. 44.) However, as critical as this World Watch document is towards the program of high-level waste disposal, not just of the United States, but for all nuclear power countries, Lenssen does note: "In recent years, a growing number of independent environmental researchers have endorsed the concept of long-term, on-site storage of nuclear waste." He is not in favor of a monitored surface storage site in which fuel would be brought together, but dry-cask storage on utility sites seems to be within his framework.

Part of the difficulty in reaching a conclusion that a repository should be constructed now is related to the uncertainty of the estimates of long-term releases. In 1991, the OECD published an international collective opinion "Disposal of Radioactive Waste: Can Long-Term Safety Be Evaluated?", which states "...it is recognized that the long-term safety of the solution offered must be convincingly shown prior to disposal." It is "convincingly" that those opposed to going ahead with a repository have not been shown, i.e., they do not believe that a convincing case has been made that the current repositories will be long-term safe. This OECD document goes on to state "Absolute proof of continuing safe behavior is impossible for all technical systems, including radioactive waste disposal systems. What must be achieved is a convincing and indirect demonstration that the proposed disposal system provides a sufficient level of safety to both current and future generations."

This statement really says nothing to resolve the dilemma. Because what are "convincing" and "a sufficient level of safety" are quite different for those opposed to a repository now and those
advocating a repository now. The terms "convincing" and "sufficient" are judgmental, not objective. In the sections under "Judging Safety", the OECD document states "The treatment of uncertainties and safety assessments is, however, part of a wider issue: the necessity of building confidence in disposal system safety." (emphasis in original). At least in my country, confidence must be built in the process, not just the disposal system, and it is that process, at the moment, in which there is little confidence.

**Intergenerational Equity**

In addition to local objections to a repository and concerns about safety of the local (or current world) population, considerable discussion has focused on future generations -- what is the responsibility of the current generation to future generations, and how should that responsibility be met.

Some views are straightforward:

"...it seems clear to me that we should not punish our children and grandchildren today, in order to fend off wholly imaginary demons in the unforeseeable future. The human race itself is going to have a hard time surviving the 21st century in the face of uncontrolled population growth and other hazards, and our primary responsibility to future generations, towering above all others, is to leave them conditions under which they have a chance at survival. The misanthropic assumption that everything we leave them is bound to be bad is not supported by history....the technical problem of spent-fuel storage has several entirely feasible and satisfactory solutions...those who work so hard to prevent its solution must have a grudge against tomorrow's people. Why else would they seek to obstruct the reasonable solution of today's problems, solutions that can contribute to a better world for our children? Remember that the people of ten thousand years ago lived before any recorded human history. Then ask yourself how, even with the best of intentions, they could have made any contributions then to the solution of today's problems, like nuclear war or measles. It is just as absurd for us to try to project our own parochial values that far into the future." (Opening remarks by Harold Lewis, Chair of Panel on People Issues at Yucca Mountain, American Nuclear Society, New Orleans, LA, June, 1994.)

Several international organizations have supported the concept that future generations should be exposed to no greater hazard or risk than current generations. In its "Principles of Radioactive Waste Management" (Safety Series Number 111-F, February 19, 1994, draft safety fundamentals), the IAEA states: "The objective of radioactive waste management is to deal with radioactive waste in a manner that protects human health and the environment now and in the future without imposing undue burdens on future generations." (Paragraph 201).

The preceding paragraph 314, IAEA Principle 4, "Protection of Future Generations", states that "Radioactive Waste shall be managed in a way that predicted impacts on the health of future generations do not exceed relevant levels that are acceptable today." Principle 5, "Burdens of the Future Generations", states "Radioactive Waste shall be managed in a way that will not impose undue burdens on future generations." Principle 5 is explained as being "based on the ethical consideration that the generation that produces waste should bear the responsibility to manage it." (Paragraph 315).

This document explicitly takes the position that it is the responsibility of the current generation to dispose of the material. The document goes on to say "Some activities, however, may be passed to a succeeding generations, e.g., the continuation of institutional control over a repository." (Paragraph 315).

Those most strongly supporting building a repository as soon as possible argue that the generator of the waste received benefits and, therefore, should handle the problem. In another
version, this is called the "polluter pays principle". As you know, in environmental management, the "polluter pays principle" means that a polluting industry must pay for the cleaning up of any of the pollution it has caused. In general, industry has tried to slow down those initiatives, although some industries are extremely enlightened. In the high-level nuclear waste case, the industry is in favor of the polluter -- the utility industry and the government -- handling the waste and putting it into a repository.

The concept of intergenerational equity is difficult. Similar arguments have been made on population, on fisheries, on protection of the oceans, and on pollution of the atmosphere. That is, we must act now to protect the future. One issue that is seldom asked, and perhaps it is of only historical interest, is whether it would have been irresponsible to go ahead with nuclear power, if at that time, when nuclear power was beginning, it was known what we now know about how difficult it is to resolve the waste problem.

Some argue that actions such as siting and building a repository should require "informed consent". Since future generations are not giving informed consent to a present-day action, this argument concludes a repository should not be built. However, one can ask how can nonexistent people, future generations, have rights? Those asking this question will come from the philosophy that having a right must carry with it a responsibility. Since future generations do not have any responsibilities, then how can they have any rights?

It is true that future generations will inherit the world we leave to them. If we leave them with enormous debts, such as overpopulation, we have been irresponsible. If we can establish a concrete correlation between our actions and the deprivation of future generations, then one can clearly conclude that other actions must be taken. Therefore, we must look at any action and ask whether it is a benefit to the future generation. We have to operate in a context of uncertainty and we must accept certain risks for advancement.

If we look at the costs and benefits to future generations, a tally may look as follows:

Benefits. A major problem will not be presented to them, since the nuclear waste will have been disposed of.

Costs. If the method of disposal turns out to be inadequate, they may have a greater burden, because the waste may be more difficult to retrieve than had it been handled in some other fashion. The beneficial use resulting from any additional funds required to build and operate a repository versus storing the waste on the surface will have been lost.

However, arguing the fungibility of federal funds is never prudent. It is always easy to argue that if a project is cancelled that will free up funds for some other specific actions. Unfortunately, historical precedents, at least in my country, indicate that cancellation of a project and freeing up any monies seldom leads to those monies being targeted in the areas of those advocated by those in favor of cancellation. Cancellation of projects should be supported on the principle that going ahead with the project is an imprudent use of resources, not that there are explicitly better uses for the money.

I believe that the true cost of going ahead is the overriding of a state's wishes, or, to be more accurate, of the people of that state. There is a minor associated cost in that there may be better solutions in the future or that better understanding may modify the method of repository disposal, the location of a repository, or the concern of the public.
Impact Aid-or-Bribe

The Background Paper, asks: "Can risk, or responsibility for essential action, be imposed (on future generations) when the benefits are perceived to be incurred by others (the current generations) and, if so, under what conditions?" And "Do current generations have the right to make decisions today which would foreclose options of future generations?" (p. 9, emphasis removed.)

In the same long list of questions to be addressed is "Are resources devoted to assuring safety of radioactive waste disposal appropriately balanced with risks, given that these resources could be applied to other societal goals?" (p. 11, emphasis removed.) As mentioned, I do find that the "given" is not an accurate representation of what happens, at least in the United States. Another issue raised, "...is there an ethical basis for a 'host' community to receive some sort of compensation and recognition of the service that it is providing to society?" (p. 11).

This has frequently been characterized as a "bribe", those using this pejorative term sensing something illegal or inappropriate. On the other hand, in the United States, there had long been a tradition of providing impact aid to communities in which there were large numbers of federal installations. In the U.S., a federal government facility, such as a large military base or one of the Department of Energy's weapons production facilities, is not taxed by the local community. Of course, all of the workers at the DOE facilities and many of the employees of the military bases do live in the local economy, requiring services such as schools, fire departments, and police. Impact aid was designed to assist the local communities in meeting these additional requirements placed upon them by the presence of the federal facilities. However, proponents of significant impact aid to a local community where a repository would be located, they have been opposed on one of two grounds, either (1) such additional aid is not necessary, so long as the normal impact aid formulas are applied, and (2) such impact aid should not be provided because it is likely to make the local communities accept something which they would not, in the absence of such a lure. The concern of those advocating the second argument is that poverty-stricken communities will be forced to accept a hazardous facility because they are in desperate need of funds. This issue frequently is raised in the debates on environmental justice, where, it is charged, poor and often minority communities are disproportionately the location of unwanted facilities, such as toxic waste dumps.

Missing Elements

I believe the background papers for this Workshop illustrate two commonly missed elements of options and practices: a true mid-term solution, and consideration of the "stakeholders", i.e., those most likely to be affected by a repository.

In addressing the ethical issues involved in making decisions about a repository, it is useful to note that there are several factors, often neglected, that should be taken into account.

The people must decide the final solution. I do not see an overriding reason that this waste must be put underground now. High-level nuclear waste is not the case of some infectious disease that, if left unchecked, can cause wide-spread death. It is not the case of some natural event which could be forecast and mitigated, if action were taken early enough. Rather, it is the choice between near-term alternatives. Frequently the argument is couched as though the only options were geologic disposal, permanent surface disposal, sending the waste to the sun, or disposing of it in the deep seabed.

This list misses the actual situation by implicitly eliminating one option. The eliminated option is short-term surface storage, for example, for 50-100 years. The difficulty that I see in the United States, and perhaps in other countries, is a great reluctance on the part of the government and its advising technologists to consider that case. The overriding pressure is for something to be done
"now", even though "now", in the best of circumstances, means not for another 10-15 years. The OECD 1991 collective opinion does, in its discussion of safety assessments, introduce the concept of risk: "Consequences must, therefore, be seen in the light of how severe they may be and how likely they are to occur, in order to assess the actual risks." (Emphasis in original.) Similarly, the discussion of cost benefit evaluation in NEA/RWM/DOC (94) 1 (p. 15) does introduce the concept of discounting of long-term health risks. However, I do not find anywhere in these documents the concept of examining the relative risk of going ahead with a repository or planning on surface storage for the next 50-100 years. It would seem that is a far more logical risk evaluation to be undertaken, if one truly wishes to consider the risk of various options.

The background paper provided for this conference has the same confusion that is present in many debates on these issues, namely, the discussion focuses on short-term solutions and permanent solutions, often called long-term, without recognizing there actually is a middle term.

Furthermore, I believe the public should be the decider of what should be done. This decision should be informed and the role of the technologist is to do that informing.

A first problem is lack of understanding of what is meant by "informing". "Informing" is not merely the technologists lecturing the public: "Scientists and engineers can help improve public understanding of policy issues and policy...Listen to and discuss issues with the public. The public's resources will be used and their lives will be affected by your technologies. This listening should be a true dialogue. A public hearing should be a hearing, not, as a recent New York City Board of Estimates meeting was described in a news account, only a "public talking." (John F. Ahearne, "Addressing Public Concerns in Science", Physics Today, September 1988, p. 41).

Technologists and government and industry officials have much to learn about communicating with the public. This includes learning what should be called successful communication in a democracy: "The risk communication process -- usually with many messages from many sources -- can be considered successful only to the extent that it, first, improves or increases the base of accurate information that decision makers use, be they government officials, industry managers, or individual citizens, and, second, satisfies those involved that they are adequately informed within the limits of available knowledge. This does not always result in the responses a particular source might wish, nor does it always lead to consensus about controversial issues or to uniform personal behavior. People do not all share common interests and values, and so better understanding will not necessarily lead them all to the same conclusion. ("Improving Risk Communication", National Academy Press, Washington, D.C., 1989, p. 8).

A second issue frequently adds confusion to technological discussions on subjects in which risk of some technological activity is involved. The affected public frequently is using a different set of values than are the technologists, the industry, or the government. It is because these values are different that even if extremely good information is presented, the final public decision may be in opposition to that of the technologists. A clear example was seen several years ago in Taiwan, when initial public polls showed there was opposition for building another nuclear power plant. The utility funded a major public education program, which appeared to be quite objective and quite extensive, focused upon both the safety of the reactor as well as the safety of the surrounding areas. At the completion of this careful campaign, which both sides agreed did elevate the understanding of the public, a second poll showed that the public was now more in opposition.

A third factor is the issue of providing long-term protection of the environment. This is goes back to the irony I mentioned earlier. Both sides in the dispute argue that they are providing long-term protection of the environment. Consequently, and I accept the sincerity of their views, this is a situation where the goal is the same and therefore the debate is about the means to achieve that goal.
A second missing element can be seen by examining the list of 16 questions in the background paper, in Section IV, "Environmental and Ethical Issues to be Addressed at the Workshop". Viewed from the U.S. perspective, particularly a perspective shaped by many debates in risk analysis and risk management, I find striking the absence of anything about the rights of current generations and any questions on who should do the assessing and the judging that is called for in these questions.

A technical solution is necessary, but not sufficient. The IAEA principle shares the same flaw. There is no mention of stakeholder rights.

I recognize that there are differences between countries. Differences in cultures, differences in governmental practices, differences in the role of nuclear power, differences in energy resources, differences in financial resources, and differences in the relative perceived need for development in environmental protection. I have found it quite difficult to sort these issues out in the United States and I make no pretense of being able to provide answers for other countries. Can permanent disposal of high-level waste be done? The technical community's consensus is "yes". The U.S. National Academy of Sciences took that position as far back as 1957. I note that the Netherlands also recently took that position (May 14, 1993, "The Position of the Dutch Government on Deep Burial"): "The conclusion [of the Lower House in 1989] was that a storage facility for radioactive waste in rock salt formations in the Netherlands would, in principle, be technically feasible." It should also be noted that the final position of the Dutch government was not to go ahead with such a facility.

There is some confusion about "what is being asked". For example, can a repository be safe for 1,000 years? The answer is "yes". Can it be safe for 10,000 years? The answer is, "most likely", especially if using appropriate canister design. Will it be safe for 100,000 years or 1 million years? At this point, uncertainty can grow large.

Is a repository necessary now?

a) To prevent risk to the current public? I believe the answer is "no". There is a caveat on military waste, which has a different problem, in that some of the facilities in which it is stored are probably not safe and that the waste must be transferred from those facilities to others. Once so transferred, the answer would have been "no", it is not a risk to the current public.

b) Is it necessary now for a "restart" of nuclear power? In the United States, there are many who argue that here the answer is "yes" and they point to the California law. However, I believe cost has killed the nuclear industry in the United States and that the presence of a repository is not going to have much of an effect.

c) Then why is it necessary now? The arguments are on, intergenerational equity and ethical considerations. However, if those are the reasons, we must look at the United States in a democratic society and, therefore, take into account the people's views.

We have been told that this workshop does "not deal in any detail with specific features of licensing systems and regulatory review processes such as the setting of safety standards, consultation and decision-making procedures, the use of an independent peer review, etc. Similarly, perception, communication, and other social and public acceptance aspects related to the practical implementation and siting of specific waste disposal systems are not covered either." (NEA/RWM/DOC (94) 1, p. 6.) However, these are not merely additional features of the process to be addressed after the technical decisions have been made. In a democratic society, these are the heart of ethical practices and considerations. Leaving them out, or leaving them until last, reinforces the view of the general public who, in a democratic society are the fundamental decision makers, that the technical community does
not really want to consider their views and does not want to take into consideration the true ethical practice of involving those most effected.

Finally, I note that the background paper written for this conference does quite explicitly lean on the United Nations Conference on Environment and Development (UNCED) (usually called the Rio Conference, since it was held in Rio de Janeiro in 1992). The background paper notes that "sustainable development" as its main theme and the report defines this as "satisfying the needs of the present without compromising the ability of future generations to meet their own needs." The concept of "sustainable development", once enthusiastically endorsed, has become questioned since Rio, primarily because of its apparent emphasis upon continuing development. It is starkly true that the world suffers great disparities between standards of living, poverty levels, food, clothing, and medical care. As the ardent pro-nuclear Bernard Cohen remarked, after having studied health related effects worldwide: "...it is abundantly clear that wealth makes health, and poverty kills". (Cohen, op cit., p. 122.) Thus, with its emphasis on development, "sustainable development" may be interpreted by the developed countries that the call is for their continued development. The follow-on activities to the Rio Conference instead have begun to stress the need to constrain the developed world, while at the same time empowering the developing world to alleviate hunger, terrible health conditions, and stark poverty. The role of nuclear power in doing that is highly questionable and is an entirely different subject. I only mention this because I found it slightly unusual to find the concept of "sustainable development" being used as a framework item in the background paper.

Procedures in a Democratic Society

In 1984, the NEA Secretariat addressed: "The question of an obligation towards future generations"). The "Long-term Management of Radioactive Waste: Legal, Administrative and Financial Aspects" suggested that a reasonable compromise on the question of moving ahead now versus forestalling decision "should be based on this elementary notion of fairness: 'At a minimum, the current generation should not pose larger risks on a future generation than it would be willing to accept for itself.'" (Paragraph 17, p. 41.) In this, the NEA was quoting a 1978 EPA Proposed Criteria For Radioactive Waste. The NEA went on to suggest that "the economic and social cost of the risk should be added to this formula." (p. 41). While not going much beyond that statement, the NEA did conclude that "it seems reasonable not to bequeath to future generations[] along with the benefits of a given technology[,] risks -- or the burden of needing to protect themselves against such risks -- of a level that we ourselves would not deem acceptable of which would effectively outweigh the direct or indirect benefits they would acquire from the technology in question." (pp. 41-42). The NEA concludes that, in practice, "the political authorities will define the acceptable level of risk from radioactive waste with regard to the population for which they are responsible, taking into account the social advantages of the activities given rise to this waste and the social cost of waste management." (p. 43).

The issue then is how should the political authorities proceed, in a democratic society.

In a democracy, the people decide what should be the government policy. Thomas Jefferson, a major figure in the early formation of the United States, wrote:

"I know of no safe depository of the ultimate powers of the society but the people themselves; and if we think them not enlightened enough to exercise their control with a wholesome discretion, the remedy is not to take it from them, but to inform their discretion by education." (Thomas Jefferson, letter to William Charles Jarvis, September 28, 1820, "Writings of Thomas Jefferson", Paul L. Ford (ed), Vol. 10, 1899, p. 161).
One method used in the United States to involve the public is the rule-making procedure. In rule-making, a federal agency drafts a regulation and publishes it for comment. The public has typically 60 or 90 days to provide comments back to the agency on the draft regulation. By law, the agency is then required to review those comments and respond to them. The agency does not have to accept the comments, but does have to provide a reasonable response, in writing. Once the agency has published its final regulation, it is open to court challenge on the grounds that it did not adequately respond to the comments. The courts have sent regulations back to the initiating agency, judging that the agency had been "arbitrary and capricious" in dealing with the comments. The advantage of the rule-making process is that it does enable public policy to be set in areas in which science is uncertain, but yet a federal agency must establish a position.

Why a Repository Now?

As I mentioned earlier, I do not see a major hazard associated with surface storage for many decades, and I have not seen a risk analysis comparing 50-100 year surface storage with going ahead with a repository. I also believe that the major problem nuclear power has, at least in the United States, is cost.

In looking at the impasse the United States seems to have reached on nuclear waste disposal, I reached the conclusion ("Proceedings of the First MIT International Conference of the Next Generation of Nuclear Power Technology", MIT-ANP-CP-001, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1990.) that there are four possible solutions:

1) I refer to an individual in American History, Daniel Farragut, for the Daniel Farragut Solution. In a battle during our Civil War, Daniel Farragut, in charge of a warship, ordered his captain to go ahead full speed in spite of weapons in the water. This is frequently quoted, possibly correctly, as "Damn the torpedoes. Full speed ahead." This approach can be seen in the "decide, announce, defend" approach mentioned before and also in the Congressional selection of Nevada, as the winner of the nuclear waste lottery.

2) A second solution is the technological solution. Advocates of this approach believe that there must be a significantly improved technological fix to our current problem. They look for a method that will satisfy a risk assessment criteria. Several have been suggested in the past, included sending the material to the sun or deep sea bed disposal. Another more recently debated and discussed solution is to burn the actinides in a fast reactor. None of these approaches have proven to be economic or publicly acceptable. Most recently, in the United States, Congressional action has supported the current Administration's proposal to close down the Integral Fast Reactor program, one of whose stated goals was to demonstrate actinide burning.

3) A third is the Magic Land solution. Since there are so many objections at siting repositories, in the United States, in France, in England, and, I suspect, elsewhere, this approach is based on the belief that somewhere there is a perfect location. This perfect location would be one where no one lives now, and it can be shown that no one ever will live there. And preferably there is absolutely no risk involved in bringing nuclear waste material to that location. Although this may seem to be an absurd description, it is an inference that can be drawn from the description of what would be required for some opponents to agree that a solution would be acceptable.

I must note that I sympathize with these opponents. They suspect that no government has been serious about finding an environmentally acceptable solution.
The fourth and final solution is to wait. In this approach, an interim solution would be required, such as the one mentioned by World Watch, that is, storing waste at reactor sites, perhaps in dry storage or above-ground casks, or perhaps sending the spent fuel to a central location. This wait approach is the default that has been used for the last 30 years for commercial waste in the United States and elsewhere. Unfortunately, this solution has not obviously been deliberately chosen, but has resulted from not being able to take action. As Harvey Cox has said, "not to decide is to decide".

In a process that seems to place greater concern on future generations than the present, some argue we cannot solve the repository problem because there are too many unknowns. Others argue that we must build a repository, even if that means overriding the wishes of the local, and most affected population. Risk analyses have not been done of mid-term options. The wait option continues to be chosen.

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Dr. Flowers

I would like to ask Dr. Ahearne whether he thinks that the time scale for the implementation and operation of geologic disposal system as described by Colin Allan this morning, which is a very long term process taking a hundred years or more, is ethical or not?

Dr. Ahearne

Since you have introduced the term that you said we were not to address, namely process, what is important to stress is the process being used. The time scale is less important. In the United States we are putting in place a process that is overriding the ability of the local community to understand the issues and consequently forcing these communities into opposition. That is a fundamentally flawed process.

The time scale of a hundred years is quite ethical. The waste can be kept safe whether it is above ground or underground; I do not see it as a significant hazard. I do see that there is a fundamental problem that in a democracy people are asked to simply accept whatever solutions are being offered.
Radioactive Waste Disposal - Ethical and Environmental Considerations -
A Canadian Perspective

Fred Roots
Science Advisor Emeritus
Department of Environment (Canada)

Introduction

The national institutions and policies of any country reflect not only the practical and political problems and opportunities that the country must deal with and the political and economic means available to deal with them, but also reflect the mores and ethos of the societies that comprise the country. The mores and ethical values of each country tend to be distinctive - they are a large part of what constitutes the distinctiveness of each nation -, and are a compound result of the various cultures, histories, geographical and environmental situations, resources, economies and other influences that shape the collective character of its citizens. Thus, different countries may develop different policies and distinctive approaches to formulation and implementation of policies, even when responding to similar issues. The issues of management and disposal of radioactive waste present similar or nearly identical technical challenges to several industrialized countries, yet nearly every country has a somewhat different response. The way that this issue is being addressed reflects to a large extent the ethical and cultural characteristics of each involved country. The actions being taken by Canada and the institutions and processes through which the decisions are made are an expression not only of Canada's scientific and technical capacity but the nature and evolution of environmental consciousness and ethical values of its citizens.

Canadian Attitudes Toward Nature and the Environment

The relationship that Canadian citizens in general have to "the environment" and to "the future" differs in several ways from that of most other countries with developed nuclear energy. This relationship has influenced Canada's energy policies and the structure of institutions dealing with energy and environmental protection, and thus has influenced the Canadian approach to management of the nuclear fuel cycle. Canadian society is perhaps more heterogeneous and rapidly changing than most of its "nuclear energy" neighbours, and so generalizations about attitudes and causes are perhaps foolish; yet one characteristic that is surprisingly deep and widespread in Canada, compared with many other countries, is awareness of and concern for the natural environment. Part of this awareness comes from the Canadian climate, geography, and history. The climate, with long cold winters in most parts of the country, wide regional climatic differences, and frequency of extreme weather events makes all Canadians continually conscious of the natural environment. Canada is a predominantly urban nation - 85 per cent of the citizens live in settlements of more than 20,000 people -, yet most of the country is very sparsely settled. Most Canadians have easy access to essentially "wild" countryside, and carry a mental picture of Canada as a predominantly "natural" land. The country's economy, also, has throughout its history been closely connected with the natural environment. The indigenous inhabitants developed cultures and economies closely attuned to the varieties of climate and living resources in different parts of the country, with a well-developed regional trading network that was tapped into by continent-wide commercial fur trading companies in the
seventeenth century to establish the beginnings of "modern" European-type economic policies and administration. When European settlers came to Canada in the seventeenth to nineteenth centuries and established the present economic and political institutions of the country, they were challenged to defend against or "overcome" what seemed threatening Nature, and to make a living from her abundant natural resources; to adapt to a harsh climate and to use technical ingenuity and lots of energy to cope with it; to learn from the experience of resident natives and at the same time attempt to copy or transplant their immigrant institutions and cultures.

This complex background, compressed into a couple of centuries in a land where, compared with much of inhabited world, the environment is a difficult one in which to make a good living, has given Canadians an intense but ambivalent feeling about Nature and environment, about natural resources and about developed energy. The concern and ambivalence is displayed in our daily practices and our institutions. Canada has more artificially heated indoor space per capita than any other country; Canadians are the highest or second-highest (depending on how it is calculated) consumers of mechanical, electrical and thermal energy per capita; we spend a much larger portion of our national income on maintaining year-round transportation and communications services. Canadians are said to talk about the weather more than any other people except sailors and aircraft pilots, and it has been observed that Canadian radio and television stations devote twice as much time to weather forecasts and commentaries as their counterparts in Europe or Japan. Despite efforts to focus on cultural or other attractions, tourism in Canada, both domestic and foreign, is overwhelmingly Nature-oriented; and despite the presence of Nature on the doorstep of most cities (or perhaps because of it), Canadians at all income levels share with the Nordic countries the highest percentage of "second houses in the country" occupied only part of the year, in as natural setting as possible, to satisfy a psychological yearning to be close to a natural environment and yet, somehow, to be in control of it.

These behavioural characteristics, combined with rapid social, economic and demographic changes and changes in landscape and use of resources within living memory, has developed among Canadians in general a sense of time that is also possibly nationally distinctive and different, in general, from that of our neighbours to the south or in Europe. There is a pervasive sense of change: change in natural conditions and environment as much as social and economic change. Most citizens or their immediate ancestors are immigrants who left a more stable society and more uniform environment for a "New World" that was visibly becoming different, partly through their own efforts. Even the abundant evidence of the recent ice Age, showing clearly that the land was drastically different not long ago, reinforces a widespread awareness that both Nature and society in Canada are evolving from generation to generation. Canadians of indigenous ancestry have no less seen their entire world change under their feet, and yet their cultures, closely attuned to dynamic Nature, do not in general seek stability but place these changes in a long-term fluid perspective.

The deeply embedded collective environmental consciousness and sense of change have given Canadians in general a relatively long time perspective, without, as a whole, sharing fully the optimism for an expanding future that is cultivated vigorously in the United States or the awareness of continuity that is characteristic of much of Europe. Although there are many exceptions to any generalization, many analysts and commentators have noted that Canadians collectively tend to be more cautious and at the same time less conservative than citizens of many other industrialized countries, "addicted to moderation in excess;" as a famous Canadian author, Stephen Leacock, put it, but ready to experiment. They appear to be less optimistic that change equates to progress, and less alarmed by disasters. This time sense and cautious gambling on the future affects Canadian investments, resource policies, and decisions about the environment. It clearly influences the approach to long-term issues like the management of radioactive waste.
Canadian political structures and institutions, also, display the national awareness and importance of natural resources and natural environment. The dependence of the economy on natural resources is reflected in the Canadian Constitution, which determines the institutional structure of the country by allocating authority over such resources, with a few exceptions, to provinces rather than to the national government. One of the exceptions where the central government has responsibility is nuclear fissionable materials and their radioactive products. The value placed by Canadians on the natural environment in terms other than economic utility is shown by many examples in which Canada has led other countries in acts to preserve or conserve natural values. Canada was one of the first countries to set aside forest reserves and national parks (the first Canadian park in 1887 "to maintain natural beauty for all time for the benefit and enjoyment of future generations") 1. In contrast to the "conservation movement" in some other countries that was led by a few concerned and influential individuals, environmentally related political developments in Canada have been based for the most part on widespread public interest, well before "environment" became a political term. Public concern about the disappearance of well-known animals led to establishment of preserves to protect bison (from 1914), prairie antelope (from 1916), and Canadian leadership in international legislation to protect migratory birds, and polar bears. Although there have been game wardens to protect private or royal lands for many centuries, Canada appears to have been one of the first to establish a "wildlife service" as a government office, with nation-wide responsibilities for conservation rather than management for exploitation. Today, Canadians support a network of parks, preserves, reserves and conservation areas established at all levels of government; citizen committees with political influence continually monitor the status of wildlife and wild plants. Environmentally-minded industry enjoys a rapport with citizen vigilante groups that, while not without clashes and disagreements is co-operative to a degree unusual in the United States or Europe. Canada’s flag carries not the colours of its political history but a natural symbol endemic to every province: a common maple leaf. And our national symbol is not an animal of power or dominance, but a ubiquitous hard-working rodent who uses the natural environment for practical purposes: the beaver.

These examples of the consciousness of nature, environment and changes with time in the Canadian psyche are manifest in the national approach to modern environmental issues. When in the late 1960’s the effects and threats of industrial pollution and inappropriate land use called for political action in many industrialized democracies, several countries responded by creating ministries or offices for environmental protection. The Canadian government accommodated the widespread environmental ethic not by emphasizing pollution control but by bringing together, under a single Minister, the "positive" environment-related functions that had until then been parts of disparate Ministries: meteorological services, forestry, wildlife, fisheries, hydrology, marine science - and adding to them an environmental protection unit. Such an approach fitted well the Canadian jurisdictional structure and the Canadian mood that the environment in all its forms was a dynamic natural resource and the setting for all our actions, but it was out of step with many other countries in which political action in the environment meant confrontation with polluters and authoritative defense of environmental quality. Canada however attempted to promote this concept in playing a strong role in the United Nations Conference on the Human Environment in 1972, ² and in the establishment of the United Nations Environment Programme. In 1974, an in-depth review of the organization and outlook for environmental policy responsibilities in Canada concluded:

"The co-ordinating role of the (federal ministry of environment) needs to be strengthened, not at the expense of its pollution control operations, but as an essential part of long-term integrated national planning. This commitment would bear witness that our irresponsible "smash it and patch it" days are over, that we now accept the role of "custodians for the future" - and that Environment is no longer a purely physical concept but one with ethical dimensions." ³
It is within this institutional policy and ethical context that Canada has developed its approach, policies and programmes for management and disposal of radioactive waste.

The Development of a Canadian Radioactive Waste Management Policy

Design of Canadian nuclear fission power reactors started in the 1940’s and the first plants were put into commercial service in 1962. All nuclear power plants in operation in Canada are heavy water (D₂O) moderated and use natural uranium fuel in UO₂ pellets. The fuel wastes from such reactors, after average burnup of approximately 650 GJ/Kg U, contain about 0.22% ²³⁵U, 0.38% total plutonium (0.26% ²³⁹Pu and 0.76% fission products, mainly ⁸⁵Kr, ⁹⁸Sr, ⁹⁹Tc, ¹⁰⁰Rh, ¹²⁹I, ¹³³,¹³⁷Cs, ¹⁴⁴Ce. The UO₂ pellets are physically intact, contained within a zirconium alloy sheath in bundles each 10 cm. diameter, 50 cm. long and weighing about 24Kg. There are no plans in the Canadian programme for re-processing spent fuel or break-up of the bundles to reconditiohe waste. The current (1994) accumulated inventory of spent fuel in Canada is about 720,000 bundles, or about 1800 tons, which is being added to at the rate of 70,000 bundles per year.

As the spent fuel decays, the radionuclides and fission products migrate to or are developed at boundaries of UO₂ grains, gaps between pellets, and on linings of sheaths or bundles of containers. Some fission product gases are produced (⁸⁵Kr is of short-term concern). The fuel bundle is highly radioactive upon removal from the reactor. After storage for one year in water-filled bays, the radioactivity typically decays to about 7.3 X 10¹⁴ Bq per bundle, with heat output of 78 watts. With the presently constituted fuel and bundles, radioactivity will fall to 7 X 10¹² Bq after 100 years, with heat output about one watt; and to 1.5 X 10¹¹ Bq and negligible heat after 10,000 years.

The long-lived radionuclides in the typical CANDU spent fuel - ¹⁴C, ⁹⁹Te, ¹²⁹I, ¹³⁵Cs, ²³⁴,²³⁸U, ²³⁷Np, and ²³⁹,²⁴⁰Pu are critical to environmental safety and environmental control, and are the focus of waste disposal planning and assessment. Their specific characteristics, and the possibility of their migration into the environment, are the subjects of the technical aspects of waste disposal. It is, however the threat or perception of a possible threat of environmental or health impact from any of the nuclides individually or the wastes collectively (plus concerns over the existence of separated plutonium) and the apparent requirement for an elaborate and expensive technical facility to provide safety, that lies at the basis of the ethical concerns. Right from the beginning, Canadian nuclear fuel waste gives rise to two different kinds of concerns:- engineering and ethical.

Technical studies to develop a concept for safe disposal of nuclear wastes started in Canada about 1970, with examination of the potential of various rock types for underground disposal. Public concern over nuclear power programmes focused largely on the perceived dangers of reactor unplanned releases and accidents, and on uranium mines. Questions of the environmental safety of the waste disposal were left mainly to the "experts". The first formal Environmental Assessment and Review of a proposed nuclear generation station installation in Canada, for Point Lepreau, New Brunswick, in 1974-75 (which also was the first occasion in Canada when an open public hearing was conducted under the newly established Environmental Assessment Review process), gave surprisingly little attention to the issue of waste disposal. Although the submitted briefs were 5 to 1 against the proposed nuclear power plant, almost all were concerned with fears of environmental damage from routine discharges, particularly into productive coastal fishing waters; with questioning the need for more electricity; with the physical safety of the proposed plant; and with the political decision-making process. In its report (1975), the Environmental Assessment Panel accepted at face value the reassuring statement from the government agency that the fuel waste would be safely looked after by means as yet unspecified, but added:
"The Panel feels that government policy with regard to long term storage, and ultimate disposal of highly radioactive wastes should be developed expeditiously. Furthermore, in development of this policy, public discussion on salient points should take place." 

In 1975, Atomic Energy of Canada Limited, the government agency responsible for developing the technology of nuclear power in Canada, decided to focus research on radioactive waste management on the concept of permanent disposal in plutonic rock in the Canadian PreCambrian Shield. A primary reason was that such rocks were abundant and the chances for finding a suitable site were seen to be good in the same region and political jurisdiction where the main production of fuel wastes could be expected in the next decades. Increasing public pressure for a national policy that would address safety and environmental concerns over wastes from nuclear reactors, and the need for a policy that would guide both the utilities and the regulators led to establishment in 1977 of an independent study on the magnitude and nature of the problems of long-term storage and disposal of radioactive wastes. The study focused on technical aspects and on safety to humans. Its report, which became known as the Hare report, was delivered in August 1977. It concluded that "there are good prospects for the safe permanent disposal of reactor wastes and irradiated fuel", and foresaw no reason to delay Canada's nuclear power programme, provided the government undertook a recommended research and development programme. Among the various options for disposal, the study group considered deep underground disposal in igneous rocks to be the most promising. It recommended that there should be initially one site, located in Ontario, owned and managed by the federal government, but paid for by charges against the organizations producing the wastes. However, the Government of Canada should finance all the costs for developing the technology for safe storage and disposal of radioactive wastes. It also recommended that "no commercial fuel processing plant should be approved in Canada until fully satisfactory methods for dealing with the associated wastes had been developed". It was the opinion of the study group that "we expect no environmental or health impacts once the wastes and irradiated fuel have been emplaced in the depository."

Despite the fact that it was widely criticized on both conceptual and technical grounds, even to being publicly called "an embarrassment to the Canadian scientific community" by a leading Canadian scientist in the subject, the Hare report became a principal basis for Canadian policy and institutional developments with respect to nuclear fuel wastes. The recommendations facilitated formal endorsement and financial support for research and technology development that was already started by Atomic Energy of Canada Limited. At the same time, the focus on technical issues and the fact that ethical questions or environmental values were ignored by the Hare study, just at a time when environment impact assessment processes were receiving much attention in Canada and public concern about the way that nuclear power issues were being made had led to powerful but responsible citizen's groups like the "Committee on Nuclear Issues in the Community", served in a paradoxical way to enhance public awareness of the role of waste disposal in the public debate over environmental and ethical aspects of nuclear power as one of the energy options for Canada.

In 1978, the governments of Canada and of the province of Ontario entered into an agreement to co-operate in the development of technologies for the safe, permanent disposal of Canada's nuclear fuel waste. Under this agreement, the federal corporation, Atomic Energy of Canada, Limited, is responsible for research on immobilization and disposal of waste material, while the provincial utility, the Ontario Hydroelectric Corporation, is responsible for research on interim storage and transportation of spent fuel. This agreement has led to the initiation in 1981 of a co-ordinated long-term research and development programme: the Canadian Nuclear Fuel Waste Management Programme, that was to lead to a "concept" for waste management and disposal that would be submitted to formal environmental assessment and review, with public examination, for approval before a disposal site would be selected and a disposal programme would be embarked upon. This programme then became the focus of Canadian public and policy interest regarding the technical, philosophical and financial aspects of radioactive waste.
In 1984 and 1986, the Canadian licensing and regulatory agency, Atomic Energy Control Board, issued "consultative documents" that set forth the criteria to be met by a depository for radioactive waste before it would be approved in Canada. The general requirements are that (a) burdens placed on future generations must be minimized; (b) the environment be protected; (c) human health must be protected. The criteria stipulate that the region in which the depository is situated should be geologically stable, that the host rock should be shown to be capable of withstanding stresses imposed upon it or caused by the depository, that the risk to humans from radioactivity emissions from the waste be predicted quantitatively for at least 10,000 years (with an acceptable level set at less than $10^6$ serious health effects per year), and that reasoned arguments must be presented that there will be no dramatic increase in risk following the initial 10,000 years after closure. These criteria provided the "targets" for the Canadian Nuclear Fuel Waste Management Programme, and for the public comment and criticism.

Establishment of Formal Assessment and Review Process for a Nuclear Fuel Waste Disposal Facility

In September 1988, Atomic Energy of Canada Limited submitted for assessment and public review its concept for disposal of nuclear fuel waste. The Federal Environment and Assessment and Review Office (FEARO) set in motion the formal process of environmental assessment, and the Minister of the Environment appointed in October 1989 a Environmental Assessment Panel of independent citizens to review the safety and environmental acceptability of the AECL concept. The Panel conducted a series of public information and "scoping" meetings at various locations across the country to obtain a perspective of the views and concerns of citizens, businesses, environmental groups, indigenous and religious organizations and government agencies at various levels with respect to the most important questions that should be addressed in an assessment of the social, technical and environmental acceptability of a concept for geological disposal of nuclear fuel waste. Based on these hearings, on its own discussions, and with the aid of an arms-length scientific advisory body of technical experts, the Scientific Review Group, the Panel issued in March 1992 "Final Guidelines for the Preparation of an Environmental Impact Statement on the Nuclear Fuel Waste Management and Disposal Concept".

The guidelines state in detail the issues to be addressed by the Environmental Impact Statement. The statement is to outline the scope of the problems presented by nuclear fuel waste in Canada, the management and disposal concept, the characteristics and the expected performance of the components of the concept. The guidelines require the proponent to forecast and explain the social, economic and environmental impacts of the implementation of a disposal facility and of the contents of the proposed disposal vault on humans, human communities and the environment to be expected at the site to be selected if the concept is approved. The proponent is required to consider the different viewpoints of society when presenting its Environmental Impact Statement, particularly the viewpoints of aboriginal peoples and the viewpoints of other public groups that have a significant potential of being impacted. Ethical and moral perspectives, along with social issues are to be addressed as providing the broader context for focused considerations of a technical, scientific and economic nature. The guidelines also ask the proponent to consider and discuss the changes in human communities and the natural environment that can be expected over the period of time that the facility is designed to be effective in accordance with the AECL criteria, and how such changes may affect the performance of the facility. The risks of unforeseen events and their environmental, health or social consequences are to be considered, and "the EIS should also discuss the ethical dimensions of disposal vault closure in relation to possible long-term impacts on humans and the natural environment."

The Guidelines issued in March 1992 form the basis of the Environmental Impact Statement currently being prepared by Atomic Energy of Canada Limited which, as of this writing, is scheduled
to be submitted to the Panel in October 1994. This Statement is being preceded by nine Primary Reference Documents that provide technical detail to various aspects of the concept. These documents are all public and will be the basis of comment and review by the Panel, by its Scientific Review Group, and the interested public.  

Studies of the Ethical and Risk Dimensions of Nuclear Waste Decisions in Canada  

In view of the evidence of an increasingly important role that issues of risk and of ethical values would play in the assessment of the public, policy, and environmental acceptability of a generic concept for management and disposal of nuclear fuel waste in Canada, the Panel in 1992 identified a small advisory group, the so-called Risk and Ethics Team, to look in more depth into those aspects of the subject that were of social concern but were not amenable to resolution by study and analysis from the physical, biological and financial aspects alone. There has been much attention in recent years to various aspects of risk perception and risk analysis as it applies to decision-making and public acceptance of controversial decisions, and to the psychological and ethical bases of attitudes toward nuclear energy in general and waste disposal in particular. The international literature on these subjects is quite large. However, much of it describes the situation in countries where the decision-making process is different than in Canada and where the various public opinions have different complexities.  

The Department of the Environment of the federal government (Environment Canada), which has undertaken scientific studies of various aspects of radioactivity in the environment since 1974, was in 1988 committed by the Government of Canada to carrying out a review of the AECL concept assessment to ensure that all environmental factors were adequately addressed. Among the areas given attention by the Department in fulfillment of this commitment were consideration of the possible effects on environmental processes independently of their current or perceived importance to humans, and of the various dimensions of assessment of social acceptability. In its interim 1992 report "Defending the Environmental Standpoint", the Environment Canada study group pointed out that standard methods of public involvement and social assessment cannot be used for assessment of a concept that is at the time of review only a proposal, because no specific site or environmental situation is being assessed, and because the long period in the future during which protection must be assured makes evaluation based on experience or comparisons impossible. Therefore, analysis of physical or economic or cultural impacts must be replaced by discussion of broad national or regional perceptual issues. These issues are based in ethical concepts and societal values which must be openly recognized and respected if the concept is to be assessed by the authorities and the public. The group recommended that direct involvement of the public must be assured at all stages in decisions about the waste disposal process from concept assessment to siting and construction; and that education and community discussion be genuinely two-way, rather than provision of information from the technical experts to the public, as has commonly been the practice in the past. It suggested that separate but related strategies be developed for dealing with public involvement and with social impact assessment, and that social acceptability based on moral and ethical values will be as important as technical acceptability in terms of assessing the overall acceptance of the concept.  

The Environment Canada teams have further pursued investigations into issues raised by various assumptions and lines of evidence related to the relative responses of humans and other living organisms to different levels of ionizing radiation, and are examining the claim sometimes made that if human beings are adequately protected, the living environment as a whole will be protected.  

The various published studies on risk and ethical questions, the questions raised by the recommendations from Environment Canada, and the wide range of thoughtful opinions expressed by a variety of Canadians at the "scoping" meetings organized by the Panel, have provided a basis for
some comparison and analysis of Canadian attitudes toward radioactive waste disposal and the
Canadian environmental assessment process.

The Canadian Societal Response to Issues of Radioactive Wastes

The terms of reference of the Environmental Assessment Panel state that in its review of the
safety and acceptability of the management and disposal concept developed under the Canadian
Nuclear Fuel Waste Management Programme, the Panel will take into consideration "the degree to
which we should relieve future generations of the burden of looking after the wastes". It was also
instructed to examine the "social, economic, and environmental implications of a possible future
nuclear waste management facility". Thus the Panel is obliged to take ethical and environmental
considerations, together, in its review.

In accordance with this remit, and in anticipation of the Environmental Impact Statement that
will address a wide range of social, ethical and environmental issues as required by the Guidelines,
the Panel and the Risk and Ethics Team have undertaken and commissioned a number of studies.
These studies have reviewed the published literature and analysed the material submitted to and
presented at the "scoping" meetings held by the Panel across Canada, in order to elucidate the value
systems adhered to by those who generally supported nuclear-generated power and the concept of
geological disposal of the wastes, and by those who in different ways were opposed to or highly
sceptical of the nuclear fuel cycle as a component of energy generation in Canada. In some cases,
the different value systems were directly apparent from the literature or the presentations. More often,
they were more subtle and became apparent only when several statements were grouped or
compared.

Even though it is not the mandate of the Environmental Assessment Review Panel for the
Nuclear Fuel Waste Management and Disposal Concept to examine the energy policies of Canada and
its provinces or any aspects of nuclear power plants as such, it was no surprise that during the
"scoping" hearings the public did not accept this limitation, and insisted in commenting on the whole
nuclear power "business" and not just the matter of waste disposal. The published literature on
radioactive waste disposal, also, frequently puts the examination of the technical aspects of waste into
the context of the system that generates the waste and makes the policy decisions about its
management. These broader viewpoints have helped make apparent the underlying value systems
to which people adhere, and which condition their approach toward acceptability or rejection of a waste
disposal concept.

An understanding of the value systems held by people concerned about or likely to be affected
by the use of nuclear power for electricity generation is an important part of assessing the ethical and
subjective environmental implications of decisions about management and disposal of radioactive
waste. The concept of risk to health from buried waste, mathematically very small and outside direct
human or medical experience and yet overlain with all the associations of wartime holocaust, reactor
accidents, and mistrust of mysterious highly technical science, is as much psychological as rational;
and the very long time frame for safety criteria, longer than the time span of human civilization, places
the evaluation beyond the analyses of economics and political forecasting. Thus it must be societal
value systems - gut feelings that whatever is done is correct and sensible or is somehow "terribly
wrong" - that determine acceptability or non-acceptability.

The issues raised by nuclear fuel disposal and the policies and decisions that must be made
about it fall in Canada into two main categories. There are convincing arguments that we must take
a pragmatic and technical view: - we have the waste on hand and are adding to it about 200 bundles
of "hot stuff" per day; it is not an immediate threat but a permanent solution or disposal will have to
be found before managing it becomes a high cost and could become a threat to health and the
environment; and the sooner we decide what to do and begin to invest in doing it, the cheaper and safer it will be for all of us and our descendants. At a somewhat different level there are genuine concerns about the fact that we have the stuff in the first place; that emphasis on processes and technical details of dealing with the problem presently on our hands may be lulling society into acceptance of an intractible problem and encouraging industry and the economy into continuing practices that will make the future problem worse. Both of these categories are issues of genuine concern about the present and future environment, and about the safety and well-being of present and future human generations. It is probable that many Canadians appreciate, quite strongly, both categories of concern. In Canada at least, the issues and debates are more complex than pro-nuclear and anti-nuclear, although there is some of that in facile statements and, as elsewhere, nuclear power issues and waste disposal issues are used as vehicles to express dissatisfaction with government, business, industrial power, or the decision-making "Establishment". But the deliberate and protracted public assessment of a concept for disposal of fuel waste, which will take at least six years of investigation and discussion before approval is given to select a disposal site and thereafter another fifteen years and a lot more money under continual public scrutiny before any waste is actually "disposed", has given Canadians at large a chance to examine their own value systems and sustained ethics, to put nuclear energy and national and regional energy policies into a larger and longer-term economic and societal perspective, and to consider not only the costs and possible consequences of any decisions made at this time but also the costs of no action.

Differing "World Views" and Value Systems

An analysis of the values expressed in the presentations and submissions made to the scoping hearings held across Canada in 1990 shows that, at that time, Canadians expressing themselves on the subject of nuclear fuel waste management did so, in general, from the basis of one or other of several distinct "world views" about society, economy, environment, and the place of humans as individuals or as citizens. The following comments in this section are based mainly on the work of Ann Wiles, who is undertaking a detailed scholarly analysis of the ethical assumptions revealed in the interventions.

One social value system, which for simplicity I shall here call the energy/economy position although that term does not describe it very well, holds that economic growth is the essential means, at least in the present century, to drive the improvement in material conditions so needed in the world; and that improvement in material conditions is a pre-requisite to improvement of human health and social conditions. Science and technology are essential and must be applied to utilize natural resources and to manage the environment to achieve both economic and social goals. Such a position holds that those with expert knowledge in specialized fields are in the best position to recognize opportunities and dangers, assess options, and to take decisions, and indeed have the obligation to do so in the interests of society at large. Under such a world view, individual efforts as well as economic and institutional activity, although undertaken for their own sake, contribute to the whole and to society at large. Differences in status, authority, and reward reflect efficiencies or inefficiencies within the system and differentiation among individuals with specialized skills and knowledge, but do not diminish the unity of society. This value system, which is focused almost exclusively on human activities, benefits and costs, has been dominant in the development and recent operation of industrialized societies and economies.

A different social value system, which I shall refer to as a egalitarian/nature world view, although that also is not a satisfactory label, starts from the basis that the public as a whole has a right to participate in, and not just to be informed about, major decisions that have long-term or broad consequences, and that policy decided without such participation is illegitimate. It holds that Nature has intrinsic value aside from any utility to human economic or social ends, and that human actions, to be successful must take into account the effect on and need for harmony with natural and
environmental processes. This means that society must have an inherent respect for other forms of life. Economic rationality cannot be justified as the leading social value, and net community values should transcend individual actions or values. Improvement of social conditions is not inexorably tied to material progress. It is the role of technical experts to inform the public so that they can make the best decisions taking all subjective and objective factors into account: it is not for the technical experts to make decisions. This world view lies at the centre of the ideal democratic political system, but has not been dominant in economic or corporate decision-making. It is found most strongly but by no means only, in citizens' organizations.

A third world view, perhaps unique to Canada among OECD countries with nuclear power systems in its influence on forthcoming fuel waste decisions, arises from the consensus of indigenous peoples and might be called an ecological/aboriginal world view. This view holds that human activities, individually or collectively and including all technological and economic actions, are an integral part of dynamic ecosystems, and that to separate "man" from "nature" is a convention with little meaning when dealing with environmental impact. Such a view is long-term by the standards of modern industrial and economic practices; the native cultures in Canada stress "seven generations" as a reference for accountability. It is also holistic and contextual, and resists dissecting issues into separate problems and authorities for piecemeal decisions. The logical analyses brought forward by this world-view and their relevance to many of the social and economic problems that lie at the fringes of modern industrial/economic society have probably been a factor in its increasing political and public recognition in Canada. All major policy decisions that affect the environment or a broad spectrum of society must give careful consideration to the indigenous viewpoint. The Guidelines for the Environmental Impact Statement for the Nuclear Fuel Waste Disposal Concept, for example, specifically require the proponent to "consider the different viewpoints when preparing its EIS, particularly the viewpoints of aboriginal peoples." The long-term and holistic perspective of the ecological/aboriginal view, and the fact that any disposal facility is very likely to be in a location where indigenous people have lived for a long time and have their own knowledge base, makes the ecological/aboriginal viewpoint an important factor in any Canadian assessment of a concept for disposal of radioactive waste.

There are some interesting philosophical underpinnings to these different world views as regards the approach to nuclear power and the management of fuel wastes. These are not as simple as pro-nuclear or anti-nuclear, or acceptance or rejection of a government-imposed decision system. The energy/economy value system, as expressed in the hearings, tends to accept nuclear power as a net benefit, although not without honest admission, at times, of problems, dangers, and costs. But it tends to view the pros and cons in the tradition of humanism, and judges them in the context of net direct human benefit, which is taken to be the necessary measure of the real value of all things. Such an anthropocentric philosophy places confidence in human goals and the rightness of material and social progress, and in the ability of human ingenuity and technology to transcend the limitations imposed by "nature". The natural environment is regarded as a physical, chemical and biological setting which, once its processes and characteristics are known, can be manipulated and its materials used for human purposes. Human goals and aspirations, limited by human fallibility, form the social context. Scientific fact and economic rationality lead to objective and "real" knowledge; feelings and moral judgements are subjective and "not real". The measure of achievement is technological capability and increase of materials and energy under human control for human benefit.

The egalitarian/nature world view, on the other hand, tends by and large to distrustful of or against nuclear power systems, while acknowledging their energy contribution and some comparative environmental advantages. The objections are in part because of the rigorous and unforgiving nature of the technology, the potential risks of accidents or mismanagement, and some unsolved questions of technology and safety of waste disposal, but are equally or more because of the origins of the technology, the way that decisions are made about it, the dependence on "big science" and "control by experts" against which an individual outside the system can have little influence. This value system is based in the main on an acceptance that the principles of humanity
are essentially social, not material; and that both intellectual and material success is in the long run bound up with living in harmony with nature. The whole complex of natural systems and environment is determined by processes independent of humans; humans can use those processes for their own ends successfully if they remain within "natural" limits, but if those limits are exceeded, the distortion or disturbance of nature will defeat human purposes. Although as much knowledge and understanding of nature as possible is desirable, and advanced technologies are necessary both to use the materials and processes of nature and to protect it from over-use or damage, full knowledge and certainty about the natural world can never be attained and the relationship of humans to their surroundings, and to one another, remains essentially an ethical one. A dependence on scientific so-called rationality tends to be seen as intolerant of the essential emotional, ethical and cultural aspects of knowledge that are vital to good judgement.

The ecological/aboriginal viewpoint, as expressed to date, avoids taking a position "for" or "against" nuclear power systems, but has called on the one hand for long-term energy and economic policies that will allow the optimum mixture of energy technologies and economic/industrial strategies to be selected; and on the other hand for the strictest priority to be given to the environment in all its aspects when dealing with the wastes that already exist and the energy facilities and the industrial geography that are presently in place26. Economic practices that discount the future or put faith in continued inter-substitutability of capital and labour without assessing the effect on the environment or total biosystem are taken to be unrealistic. The absence of an accepted spiritual bond between human consciousness and environmental processes, typical of most industrial and management thinking, is seen to be a practical as well as a philosophical handicap to long-term progress. As humans and their technical toys are inescapably integral parts of but also strong perturbers of a dynamic ecosystem, the idea that "Man" can act separately from "Nature" or that there are natural limits within which humans can operate without affecting their surroundings is viewed as a self-delusion26. Science and all forms of knowledge are useful and desirable, but human experience and wisdom accumulated through generations should remain the basis for judgement, even on questions such as radioactive waste disposal that are new challenges, different in detail but not in context, to those with which humankind has always had to deal.

These different viewpoints appear to lead to interesting divergences in the matter of credibility and trust, and in use of the established Canadian Environmental Assessment and Review Process to achieve an "acceptable" nuclear fuel waste disposal system. For those with a typical energy/economy world view, credibility is largely a matter of approved credentials. Expertise and relevant experience must be earned through qualifications and performance in the field of interest; they imply accountability to the public or the authorities who can discredit them or undo their work if they fail. Credibility also depends on a common assumption or trust that actions taken, whether within an institution or for an employer, will in net effect be for the good of the public. It depends upon the sharing by the public in the confidence that the most reliable knowledge is based on objective information evaluated or interpreted by technical experts. Thus it was evident from the "scoping" hearings that the organizing principle for interventions on basic questions to be addressed in an environmental impact statement was the adequacy or otherwise of objective fact. There was acceptance that the best decisions will be based on competent knowledge of physical reality and biological response, and therefore technically sophisticated expert advice to the Assessment Panel is essential. Those who do not have the education or training, or have not applied themselves diligently to the issues, are in this view insufficiently informed to contribute to the decisions. It is the obligation of the expert to protect the uninformed public and act in its interest. This, it is felt, is what the public expects and pays for. Those who hold these value systems tend to accept the established Environmental Assessment and Review Process as a vehicle through which the best and most convincing technical information can be laid before the Panel in such a way that the Panel can make a transparent and accountable technical decision that will be acceptable to the authorities and to all but the irrational segments of the public.
For those whose interventions are based on an egalitarian/nature world view, credibility does not appear to lie in better and more objective data. There is evident a decline in confidence in experts and centralized "decision-makers". Disillusion with science is not so much because it is felt to be in error, or that it is biased, although there is often suspicion or evidence that it is, but that it is not telling the public or the authorities what they need to know. Science and fact-gathering are felt to be addressing irrelevant questions, or to be working toward goals not accepted by society at large. Some go so far as to say that the industrial and scientific establishment are pursuing invalid goals in the service of a disintegrating socio-political and economic order. In this world view, trust and credibility is earned only through demonstrated sharing of common values, and independence from the established economic and vested interests who promote the practices that exacerbate the problems. The organizing principle around which assessment of the concept must be built is broad public participation. Those who wish decisions to be made must provide ample information to the public, not on technical details but on fundamental issues, alternatives, and possible consequences. Public values, in a range that reflects the heterogeneity of society and of its goals, must be expressed in policy, and the policies must reflect the ethical nature of public responsibility. Cultural values, in all their complexities and contradictions, but particularly their relationship to the natural environment, are essential factors in any decision with long-term implications. It is imperative that a decision that leads to a long-term policy and financial commitment with irreversible consequences, as is the case for some objectives and schemes for permanent disposal of nuclear fuel wastes, not be made by a small group of experts based on available technical data and current policy and financial exigencies. Such decisions must be made by direct participation of as broad a range of the public as possible, in the light of ample information. Those holding these views see the Environmental Assessment and Review Process not as a vehicle for assembling the best and most complete information leading to expert decision, but as a public forum where a range of fundamental questions can be asked and discussed, and the values of society at large placed against the values and priorities of the political, industrial and economic establishment. They see Panel members not as arbiters of information but as guardians of the range of societal goals, who will not be swayed by scientific double-speak, and whose main task, and strength, is to apply rare common sense.

Credibility, within the ecological/aboriginal world view, is usually stated to reside in the accumulated experience and wisdom of those who have been a highly sensitized part of nature as well as part of humankind through a variety of conditions and stresses, and in whose judgement the community has confidence. Such persons are commonly called "elders", but there is no term in the European languages that adequately addresses the concept. Repeated experience, largely unfortunate, with the policies, commitments and changing practices of European cultures has led to a scepticism about their value and dependability. The emphasis on short-term human economic gain is seen to be immature and ephemeral, and the disassociation of human actions from environmental responses unworkable; both of these habits of industry and government are stated to be incompatible with an announced intention to demonstrate environmental safety of radioactive waste over thousands of years. The organizing principle for assessment of a waste disposal concept is seen to be essentially spiritual: is the proposed facility acceptable to "Nature"? The elders are in the best position to judge this; they will welcome and consider all available technical, environmental, and social-impact information, but not rely on it. The Environmental Impact Assessment and Review Process is viewed as an essentially government institution, well-intentioned but subject to pressures, influences, policies, time and budget constraints that may obscure the real issues and make it hard to keep a sense of proportion. The biggest limitation, in this world view, is that the Panel is obliged to make recommendations only on nuclear fuel waste disposal and not on energy policy or industrial and economic practices that give rise to the need for energy that promotes the practices that produce the waste. Thus the main issues are not being addressed by the Panel, and, accepting the reality that the Panel mandate cannot be changed, the main area where this world view can have an influence will be later, on a local scale, when sites are selected and construction of a facility is started.
Analyses of Risks Associated with Fuel Waste Disposal

Coincident with the studies of societal value systems held in Canada as revealed in the submissions and interventions in the public "scoping" hearings, the Scientific Review Group and Risk and Ethics Team undertook investigations into the subject of risk analysis as it may be useful to the Panel in its evaluation of the Environmental Impact Statement and of the submissions that may be brought before it at the final public hearings. In this work, the teams have benefited greatly from the researches of Professor Lind27 and Professor Brunk28, both of the University of Waterloo, Ontario, from whose writings some of the following comments are taken.

Concerns about the safety of nuclear power systems were inherited from the historical beginning of fission energy applications in the Second World War, and have led to many studies, in several countries, to assess the safety and risk of accident or possible harm from nuclear reactors.29 Gradually, some of these assessments began to include discussions and analyses of the possible hazards of wastes. The Atomic Energy Control Board, in its 1987 "guidelines"30 selected some levels of risk to human health that became target criteria for the Canadian Nuclear Fuel Waste Management Programme.

Almost all of these studies were concerned with "probabilistic" risk, and followed, and in some instances contributed substantially to, the advancing science and methodology of probabilistic risk assessment. They were concerned with: What is likely to go wrong? What are the probable consequences if something does go wrong? How likely is something harmful to happen? How good are the detection and control systems and possibilities of prevention or mitigation? Most such analyses then devise some procedure for comparing the probability of an incident and the magnitude of likely harm with other systems, or with costs and benefits. Such analyses and comparisons can be formalized and in their operation (although not in the identification and ranking of different types of harms) can be objective and largely mathematical.

When nuclear power systems are analyzed according to Probabilistic Risk Assessment Procedures, they almost always turn out to be very "safe" in comparison with other power systems or other common risks that the public in industrialized countries accept as part of modern living. And yet the evidence is clear that in many countries, large segments of the public are not reassured by these analyses of comparative safety, and continue to feel, sincerely, that the risks to humans and the environment, in the short term or the longer-term future, are unacceptable.

The lack of acceptance by the public of the results of analyses and comparisons of probabilistic risks of nuclear power systems, is often felt, by those in the risk analysis industry, to be due to failure of communication of the nature of risks, and to a blindness of much of the public to the risks that they are already accepting from other sources. There has been considerable study of this problem. In the industrial area in general, management practices in Canada have reached a considerable degree of sophistication so that risk assessment and communication can be a positive tool for decision-making on investments and modification of commercial processes.31 Canada has issued the world's first formal standard guidelines for risk analysis for small and medium-sized technical installations.32 However, while acknowledging that factors of culture and ethics which are essentially non-quantifiable and non-transferable or comparable are important to social satisfaction or acceptance, these risk analysis approaches remain safety-oriented, and search for quantitative indices of social well-being.33 They thus appear to miss the main area of rejection by the public to technical risk analysis of issues such as nuclear power systems, where the areas of concern are not probability of accident or harm but its possibility, no matter how remote; not the multiple safety features in the design but the very need for them; not the statistical proportion of risks but their distribution in place, in time, and in society.34
Some of the studies of the safety and costs and benefits of nuclear power systems in Canada have recognized, from the beginning, that major issues in the acceptability by the public could not be addressed by quantitative risk analysis or by assessing risk of environmental change purely in human benefit values. The 1980 report of the Royal Commission on Electric Power Planning stated:

"It is impossible to understand the nuclear debate without understanding the different world views which underlie the two sides of the debate... Different world views [reflect] different visions of reality... The debate about nuclear power has evolved into a debate about the most fundamental values of society"\textsuperscript{45}.

and

"It is not a trivial matter to balance the worth of a dead turtle against the value of a megawatt of power available at the flip of a switch. The people of Ontario must be encouraged to think carefully and seriously about the irreversible tradeoffs they may be making, step by step, between convenient power now and a permanently impoverished natural world. At some point, an impoverished natural world leads inexorably to an impoverished human society and an endangered human race. We have a responsibility to assess the importance of the effect [of expansion of nuclear energy systems] on wildlife in terms more basic than short-term economic profitability and 'practical' convenience\textsuperscript{46}.

However, despite these acknowledgements that the questions of risk must consider non-quantifiable ethical and environmental values, the major reviews of risk of nuclear power systems have remained technological, analytical, and focused on probabilities of safety\textsuperscript{37}. The public responses in Canada, however, increasingly have stressed areas such as effects on ecosystem productivity, genetic diversity, environmental resiliency, fairness in distribution of risks among society, and the social risk of increasing dependence of the public on a technically sophisticated elite\textsuperscript{38}. These challenges have moved nuclear risk issues from technical risk analysis to the field of ethics and environmental valuation.

The assessment of potential risks from a concept for waste disposal that has never been implemented, at a site yet to be chosen, and whose safety is to be assured for thousands of years beyond any foreseeable social, economic or political system faces particular difficulties of credibility and acceptance. The uncertainties of "what can go wrong?", "how serious could it be?", "how likely is it that we have not today thought of everything that might happen centuries from now?" are made more difficult by the fact that disposal of the type envisaged has not been done yet, there is no way gradually "to learn by doing", especially if a prime objective is to relieve future generations from the burden of having to correct 20th century mistakes. Radioactive waste risk assessments are further compounded because it is clear that the distribution of benefits and costs are very skewed from the beginning: the benefits are in the present, and the unquantifiable costs, if there are to be any, to the environment and to the public, will be far in the future.

The terms of reference for the Nuclear Fuel Waste Environmental Assessment and Review Panel specifically instruct it, as noted above\textsuperscript{39}, to review the safety and acceptability of the concept, and, to consider the risk that future generations may have to bear the burden of looking after the wastes. The Panel is therefore obligated to assess the risks presented by the concept both from a technical and ethical viewpoint.
Influence of other Energy-Related Environmental Assessments

The development of a Canadian Nuclear Fuel Waste Management and Disposal Programme and the steps toward formal Environmental Assessment of the fuel waste disposal "concept" has not taken place in isolation. Both the environmental and social/ethical issues raised by the nuclear power systems and the provincial and federal environmental assessment and review processes have evolved during the period since the concept was submitted for assessment in 1988, and the evolution is continuing. These changes are inevitably having an effect on the way that the issues are described and presented in the Environmental Impact Statement and Primary Reference Documents, on the priorities and approaches of the public and institutional future intervenors, the background setting in which the assessment and review process must operate, and, no doubt, on the personal views of members of the Environmental Assessment Panel.

Of the 44 "major" environmental assessment reviews that have been conducted by the federal government, or by the federal government in co-operation with provincial environmental assessment agencies, the majority have been related to energy developments. A large number of the best-known, which have captured nation-wide attention and left a mark on subsequent policies, projects, and public attitudes, have been connected with energy developments in rural or northern Canada, where the imposition or the prospect of an economically-driven, technical, high-cost operation onto or into essentially natural environments where local people do not at present share the sophisticated urban life-style of those who are initiating the development provides opportunity for expression of the different world views and value systems that became so apparent in the nuclear fuel waste "scoping" hearings. These reviews have shown that the value systems being brought to the assessment of the nuclear fuel waste disposal concept in Canada are not specific to "nuclear issues", but are rooted in the deeply held ambivalent Canadian concern about environment and energy and the societal perspective that acknowledges continual change but is sceptical of equating it automatically with social or economic "progress". These concerns transcend the so-called "nuclear debate"; rather, they appear to be typical Canadian attitudes, hopes and worries, applied in this instance to the question of nuclear waste disposal.

The successive public interventions and debates concerning environmental assessment of a variety of energy-related major industrial prospects have revealed different facets of the Canadian environmental ethic. Inasmuch as the ethical values held by a society, or components of it, are developed over time, based largely on teachings handed down through generations but continually modified, sometimes even reversed, by successive relevant experiences\textsuperscript{46}, these assessments and the publicity attending them, have no doubt themselves had an influence in shaping the Canadian environmental ethic. In the present context, these other assessments can provide a useful perspective to the problem that the Assessment Panel must face in examining the acceptability, in the complex Canadian context, of the proposed concept for waste disposal.

The different value systems held by Canadian society in respect to a large-scale technical project that some feared would result in a long-term or irreversible change to the natural environment and possibly have impact on those who were not seen to be beneficiaries from the project, except for some local employment, was dramatically brought to the attention of Canadians in general through a study with extensive on-site public hearings, in 1975-77 of a proposal to build a 2000-Km oil pipeline from the shores of the Arctic Ocean to connect with the energy distribution networks of the developed part of western Canada. The hearings, and the very extensive socio-economic studies undertaken by the pipeline proponents together with skilful encouragement of constructive dialogue between industrial proponents and a wide range of residents, local businesses and institutions who might be affected, significantly changed both the style and the expectations of major energy-related environmental assessments in Canada. In particular, the study and review set in train an acceptance of the right of all segments of society to be heard, and built an atmosphere of official and media respect for different societal value systems. It led to credibility of the ecological/aboriginal world view as an important factor.
in making decisions that would have long-term environmental consequences in Canada. The report from this study displays in its title, “Northern Frontier, Northern Homeland”\textsuperscript{41}, acknowledgement of the distinctly different ethical perspectives that must be respected, and not over-ruled by a simple yes-or-no decision, in issues of this nature. This study has undoubtedly had an influence on subsequent environmental assessments of mega-projects in Canada, and is part of the background to the current assessment of the nuclear waste disposal concept.

Many formal environmental assessments in subsequent years show the evolving ethic. An assessment and review of a proposed project for oil drilling in a marine strait in an almost uninhabited part of the Canadian arctic recommended against proceeding because of inadequate information about the potential for impact on components of the biosystem that had no known or foreseeable human value\textsuperscript{42} - a landmark recommendation at that time, but less strange today, and a viewpoint that has relevance to assessment of unknown future effects of a buried waste depository on, say, presently unidentified microbiota. Assessments and reviews of hydroelectric projects in Labrador\textsuperscript{43} and of a natural gas pipeline along the Mackenzie Valley\textsuperscript{44} gave progressively more attention to social perception issues as well as socio-economic and "practical" environmental effects, and to the dichotomy between local aspirations and the industrial interests both of which sincerely had economic progress and environmental protection in mind. The effect that a large quickly imposed industrial project might have on shared lifestyles and traditions, on community cohesion and sense of identity were identified as integral factors to be included in environmental impact assessment\textsuperscript{45}.

A joint-federal-provincial panel reviewing the environmental effects of development of uranium mines in Saskatchewan\textsuperscript{46} gave attention to the category of "public concern" as separate from professional concern and economic importance in the criteria for Valued Ecosystem Components to be taken into consideration in environmental assessment. This review drew a clear distinction between the social impact and acceptability of a single mine and the possibly quite different effects of a series of mines or of sustained exploration and development activity. Such cumulative impacts can be positive or negative, differently to different components of society in the region. The study also drew attention to the potential importance that a perception of possible risk to health from radioactive materials, even though there may be no basis in medical evidence, can have as a "community value" factor in assessing environmental impact of the production end of the nuclear fuel cycle. A recent controversial assessment of a proposal for an irrigation dam\textsuperscript{47} has brought to the fore, and into the law courts, conflicts between the distribution of proposed economic benefits and the loss of cultural or sacred values and human rights, and shown inconsistencies in policies at different levels of government. And a current assessment of the environmental effects of military training operations in a sparsely-settled part of northeastern Canada where the residents are dependent on wildlife that are prone to disturbance but the effect on the wildlife is behavioral rather than physical has pitted quite different ethical values and perceptions of what is the legitimate "use" of natural countryside against one another\textsuperscript{48}.

This varied and cumulative experience with the purposes, operations, and effectiveness of environmental impact assessment and review in Canada, although it has not been on the subject of nuclear fuel waste disposal, provides an important part of the setting for policy decisions and public involvement, the expectations and perhaps the cynicism, in which the Assessment Panel must weigh the information and the intentions brought before it, and make its recommendations.

Common Ground and Possible Accommodation between Different Views

It is clear that the environmental, ethical and perceived risk issues raised by disposal of radioactive wastes are much more complex than can be described by determination of a boundary between "safe" and "unsafe", or by classifying those with strong opinions into two camps, one in favour and another opposed to present developments and proposed practices. In Canada at least, the issues
to be dealt with in assessment of acceptability are articulated by well-informed sincere persons who have in common a concern for maintaining a healthy environment and economy, and for the well-being of future generations, but who have quite different views about how those concerns should be satisfied. If the interests and goals of the different viewpoints are similar or shared, it is reasonable to expect that there should be areas of common ground, and that various lines of approach can each contribute to the best decisions that can be made at this time to the management and disposal of nuclear fuel wastes. It therefore is useful to search for and identify areas of shared interest, or where there is more in common between the views held than often may be recognized or acknowledged by those who hold the views.

A preliminary analysis of areas of common ground and possible accommodation between what may be called "pro" and "anti-" positions expressed in the "scoping" hearings in Canada has been made for the Risk and Ethics Team by Wiles. Some of the following comments are based on her study. In addition, experience with past environmental assessment exercises has shown that where the acceptability or rejection of a proposal can be based on what appears to be in part the interests of two or more "sides" who have quite divergent views, constructive communication can continue, rather than being terminated because one group feels it has "won" and the others are perceived to have "lost". Such accommodation or constructive input in no way needs to result in a mediocre common denominator, or to diminish the legitimacy of real differences in values. In this respect, the whole process of environmental assessment and review can be a powerful instrument of social learning and adaptive policy development.

It becomes evident from analysis of the public and proponent's stated positions that any common ground must recognize the legitimacy of quite different "core values" about society, the environment, and the role of economic factors in motivating policy or decision. If different core values, which underlie the distinct worldviews that have become evident in Canadian discussions on nuclear power and waste disposal are held to be valid and legitimate, not up for mediation or challenge, then the politicized positions that arise from them in the nuclear fuel waste management context can be examined in a non-threatening way, to identify differences and similarities in immediate goals and approaches, and to look for common ground and actions to which the respective opinions could contribute.

Wiles has identified seven areas described by ethical statements, where the expressed public and institutional opinions, both "pro-nuclear" and "anti-nuclear", show some convergence. Although the words, emphasis and implications may be quite different or even opposed in the minds of the presenters, it is evident that all sides have some agreement with the following:

1. It is desirable for Canadian society to be in a strong economic position; governments and institutions have an obligation to manage public money responsibly.
2. Credible knowledge is empirical, a product of close observation and experience.
3. Experts and specialized knowledge are influential within the scope of their fields; participants in decision-making have a responsibility to be informed.
4. Public acceptance legitimates policy decisions.
5. Those who produce the waste, or benefit from its production, should take responsibility for its disposal.
6. Future generations should not be burdened with the management of our waste.
7. Risks to environment and human health should be evaluated in detail so that they can be avoided or minimized.

For each of these areas, it is immediately apparent that there are differences in interpretation and meaning to, for example, those with an energy/economy world view from those with an egalitarian/nature or an ecological/aboriginal value system. Without disagreeing with the simple statement, each may take a different approach to questions such as: Where does economic strength fit as a driving force among other values? What is the relationship of so-called objective scientific knowledge to value-laden experiential, qualitative knowledge or spiritual insight?; What is the role of the expert with technical qualifications in selecting and defining the decisions that should be made? etc. But once the legitimacy of different core viewpoints is acknowledged and accepted, so that the purpose of the discussion or hearing is not to discredit the other viewpoints but to bring forth genuine concerns about the issues at hand, these common areas provide fruitful ground for identifying those incompatibilities that are quite intractable, and for which a decision on the proposed waste disposal will be a victory for one and a defeat for others, and the areas where differences in approach can be accommodated and each or all can contribute to a better decision. It would seem that there are many issues raised in the hearings and to be addressed in the Environmental Impact Statement where each of the different "world views" can contribute to the common objectives that a waste disposal facility should be as safe as possible prior to closure and pose minimum threat to the environment and human health during its projected life; and that public money not be wasted in achievement of this goal. Wiles has discussed for each of these ethical areas the obvious incompatibilities and differences, and the potential for commonality, that underlie the statements made at the scoping hearings. She has made some suggestions for facilitating constructive debate and building compatible positions.

Examination of the areas of commonality and convergence, however, brings into the open a serious problem for the Nuclear Fuel Waste Management Process in Canada and its current Environmental Assessment and Review. This is the relationship of the Nuclear Fuel Waste Management and Disposal Programme to Canadian energy policy and the place of nuclear fission energy in the Canadian energy spectrum. The Environmental Assessment Review Panel is mandated only to review the Nuclear Fuel Waste Disposal Concept. It is not empowered to assess and review whether the waste should be disposed of at all. Some of the "core values" underlying the world views described above have led to genuine convictions in sincere persons that to implement the nuclear power system to the extent it has been done in Canada has, however well-intentioned, been an error. The fact that we now have wastes that must be managed or disposed as safely and environmentally cleanly as possible is reality; this is not disputed. But persons holding those convictions have stated that to take part constructively in finding "acceptable" conditions for a concept to dispose of the wastes presently on hand amounts to legitimizing and approving the continued and expanding use of nuclear power and thus be sanctioning a regrettable error; this in turn will lead to continued generation of more waste. To persons who hold such views, the Environmental Assessment and Review may be seen as the only current mechanism to halt the compounding of what is seen to be a national mistake, or at least to bring about a more comprehensive review of the whole assemblage of nuclear and energy policies. If the Nuclear Fuel Waste Environmental Assessment Review Panel is to stand credibly behind its declared intention that all value systems sincerely held by Canadians are legitimate and will be carefully listened to, it will need to deal with value systems that do not accept the limitations of its mandate.

Conclusions

The issue of disposal of nuclear fuel waste in Canada, currently half-way through a formal environmental assessment and review process, has been a vehicle that has brought into the open many complex and distinctively Canadian aspects of environmental and social values related to energy, government, popular and authoritative decision-making, and what citizens value about the land
in which they live. Canadian geography, climate, history, racial and cultural heterogeneity, resources, economics and political structure contribute to a complex environmental ethic and approach to economic/industrial projects that is perhaps somewhat different from that of other industrialized countries concerned with nuclear waste disposal. At least three distinct value systems, here called energy/economy, egalitarian/nature, and ecological/aboriginal, are well developed and have political sanction and popular credibility in Canada. The elaborate and protracted formal environmental assessment and review process in Canada, transparent at all stages and with extensive public input at several intervals, gives open access to all value systems, and places the assessment and acceptability of nuclear fuel waste disposal in the context of a large number of other major, commonly energy-related assessments which have high public and political profile. The ethical and social responsibility aspects of nuclear waste disposal concept assessments have openly and officially been given importance alongside the technical and safety aspects as an inherent part of environmental assessment, and special consideration is afforded to the views of aboriginal peoples.

The issues involved in environmental assessment of nuclear fuel waste in Canada are broader and more complex than a "debate" between pro-nuclear and anti-nuclear opinions in society. They are issues that bring forth the contradictions and richness of Canadian society and its collective view of its own future. All this will have to be considered by the Panel in its forthcoming decision. Whatever the decision, that too will have an influence on Canada that will be felt well beyond the disposal of nuclear waste, important though that is.

References

(Unpublished reports are available in photocopy)


20. Reference 15, above.


23. Reference 16 above, p. viii.


29. A well-known example is -


   Canadian examples include -


30. Reference 14, above.


also:


36. PORTER A., Reference 29 above, 2nd submission from Dept. of Fisheries and Environment, p. 140.


38. See Reference 9 above for early expression; the "scoping" hearings submissions provide recent examples.

39. Reference 16 above.


45. Reference 44 above, page 42.


Ethical Questions within the Context of Final Storage of Radioactive Wastes

Herlind Gundelach
Federal Ministry for the Environment, Nature Protection and Nuclear Safety

Management of radioactive wastes represents a specific problem within the framework of the public discussion on the use of nuclear energy. In Germany, this has been the subject of lively and controversial discussions over the past few weeks and months. This makes manifest that basic differences and uncertainties exist with regard to the ethical justification of the kind of storage preferred by politics, i.e., final disposal.

It is not my task here to explain which kind of rock formations are better suited for disposal and in which way disposal should take place. Rather, my task is to address these questions for which a satisfactory answer must be provided if the procedure as a whole is to be characterised as responsible.

Ethics is part of the so-called "practical philosophy" since it strives to answer the question: "What are we to do?". Ethics teaches to assess the individual situation in order to allow action in a way which is ethically, that is to say morally right. Ethics, therefore, always deals with the standards and criteria which are referred to as "justification for the individual action".

As we have learned from the history of evolution, man cannot exist for himself alone. His existence depends both on other people existing along with him and on the surrounding environment as a basis for life. This means that his action always has to relate to three levels if it is to be characterised as an ethically good and, therefore, responsible action:
1. man is responsible for himself as an individual;
2. man is responsible for the well-being of society;
3. man is responsible for the well-being of the natural environment surrounding him.

These three levels of responsibility are of individual importance when a decision has to be arrived at. Here are the roots of possible conflicts since the interests of the individual person, the requirements of society and the justified concerns of the environment are as a rule not elements of a harmonious and pre-fabricated, stably-structured network. The target conflicts and juxtapositions of different types of good can only be solved by weighing the different aspects if action is to be responsible. It is therefore one of the tasks of ethics geared towards practical implementation to develop rules and maxims for action which can be applied generally for weighing the different solutions to come to a decision. This is where my function lies today. It is certainly not my task to give you a conclusive answer as to whether, and, if so, which method of final disposal is the right one. Rather it is my task to present ways and criteria on how to find responsible solutions for this question.

Wherever aspects of good are competing with each other and negative side-effects or risks have to be taken into account, we need an ethical method for weighing the good and evil aspects; there is no morale free of conflict and, therefore, there is no other possibility. - above all from the aspect of ethics - than to weigh the evils to be faced and to chose the lesser one.
In any case, however, the minimisation of evils must be the first step of the weighing-up process. The rule of minimisation can be formulated as follows: action which is to serve an ethically good aim can only be justified from an ethical point of view if the negative side-effects linked with it can be reduced to a minimum.

It certainly would mean to carry coals to Newcastle if I were to try to tell you, as experts on the peaceful use of nuclear energy, that the risks linked with this technology are not zero. We therefore have to ask the question as to which standards have to be applied to an action which is linked with negative side-effects that can no longer be minimised.

The second general maxim for action to be applied says: an action which is to serve a good moral aim can only be justified from an ethical point of view if the evils arising as a side-effect are smaller than the evils which would arise if the action were not taken.

Opponents of nuclear energy continue to argue in this context that it would be better in such a case not to take any action at all than to risk evil. The objection to this argument is, however, that renunciation of action is also not without consequence. For renunciation of action ultimately means not including the negative side-effects resulting from such renunciation into the decision-making process and thus the approving acceptance of even higher possible risks. Let me mention here, as an example, the higher susceptibility to disturbance of interim storage as compared to final storage in deep geological formations. I should however also like to add that this alone does not yet answer the question as to whether it is responsible from an ethical point of view.

In order to allow for a better understanding of this theoretical concept of weighing good and evil, which I have just presented, let me address its practical application and mention some focal questions which are repeatedly asked when discussing the justification of final storage of radioactive wastes. These are questions concerning: 1) the particular hazard or safety in general; 2) the relationship between the protection of present and future generations; and 3) the necessary limitation of burdens on future generations.

Re. 1): The reproach is made that it is not man's right to increase the natural hazard potential by himself contributing towards them. This is also expressed by R. Spaemann in his view that we do not have "the right to create additional hazards on our planet over and above the risks inherent in nature such as earthquakes, volcano eruptions and tornados, etc., by our transformation of the material". This argument obviously contains an erroneous premise. It suggests that it was for the first and only time nuclear energy - both with regard to use and final storage - that an artificial hazard was added to the natural hazard potential. In fact, however, nuclear technology has in common with any other technology the following aspect: any technology, be it large or small, implies an additional hazard for our planet. This argument can, therefore, not be used against a certain technological action but, at most, against technology in general - which has already been positively welcomed as a rule by our modern industrialised society. Thus, this general argument cannot be applied when weighing the good and evil aspects of a specific technology. It can, at most, be used with regard to the specific hazards and risks of such a technology.

Re. 2): It is argued that we do not have the right to impose on future generations the lasting existence of hazards such as those linked with final storage, an unchangeable fact, since we do not know whether they will still be able to cope with controlling these hazards in the year x and whether governmental institutions will still exist which guarantee the protection from hazardous impacts.

This argument is based on a concept of responsibility referring to a time prior to any historic-cultural development of mankind and, therefore, makes future generations' own responsibility superfluous or negates it. If this argument were to be followed, we should have to design our present day technological world in such a way that our descendants would not have to face any risk due to
burdens caused at an earlier stage, even if they (our descendants) underwent a backward
development to a clearly more inferior level. Such an understanding of responsibility is the result of
an extremely defensive anthropology which does not serve the purposes of the cause since it denies
the innovative character of human cultural development. As a veto, and a result of possible weighing-
up processes, it can only be argued in this context that a hazard potential may not be imposed on
future generations if control of this hazard potential cannot be accepted as a burden for the present
generation.

Re. 3): The assertion is made that man is not permitted to engage in any action which is linked
with hazards and risks if he alone benefits from its advantages while future generations only bear the
burden of the continuing hazards emanating from it. Without any doubt this idea is of highest
significance, when compared to the arguments used so far, since it is based on the idea of justice.
The present generation must not always seek advantages while placing on future generations the
burdens these advantages bring. Nevertheless, such an assertion, being an ethical statement, has
to be examined in a more differentiated way and has to be thoroughly examined. Also to be examined
is in this context the question as to whether and to what extent renunciation of an action which
involves negative consequences itself leads to effects which, in the main, can also lead to gross
impacts on the chances for life of future generations. As an example, let me mention the increased
use of fossil fuels and their effects on the climate. Let me remind you of the climate changes on our
planet with all their effects on flora and fauna, rise of the sea level, melting of the ice-caps, etc.

If we want to make progress in this matter, and want to achieve balanced-out results with
regard to an ethical assessment of final storage of radioactive waste, there is no way round
considering the whole context of relevant patterns of causes and effects.

As has already been mentioned, it is not the task of ethics to judge how far facts are stated
correctly; for example, the half-life period of radioactive substances or the physical and geological
conditions of safe final storage. Its indispensable task rather is to monitor the decisions based on
these facts as well as on a plethora of further empirical premises and the weighing of processes linked
with it and to check whether all essential aspects have been taken into consideration. With regard to
the problem of final storage of radioactive waste the following comments of a very basic nature must
be made:

1. The problems of final storage have to be considered within the wider context of the question
of disposal in general. In addition to the disposal form of final storage, interim storage which,
in general, comes prior to final storage and the disposal form of reprocessing must also be
included in the weighing-up process.

With regard to interim storage, it must be said that it always represents a provisional form of
disposal which, as the comparatively greatest hazard, requires more far-reaching solutions,
i.e., either direct final storage of the respective radioactive material or its reprocessing with
subsequent final storage of the remaining material that cannot be processed. Thus, it cannot
in any way be justified to perpetuate transitional storage as a permanent form of disposal
without there being any need for it.

With a view to reprocessing, it has to be taken into account that the use of such reprocessed
radioactive material which thus becomes possible does indeed reduce the quantities of highly
radioactive waste but, at the same time, it creates major quantities of medium and low
radioactive waste for which storage capacities have to be made available. Another problem
given here is the plutonium arising during reprocessing. When assessing reprocessing one
also has to take into account that it involves a higher risk of possibly releasing radioactivity into
the environment than final storage - not least due to its direct handling of radioactive residual
material. In any case, however, one may be sure that an option for reprocessing radioactive
remaining products only makes sense if further use of nuclear energy - be it in the short-term, the medium-term or the long-term - is considered necessary.

2. The question concerning final storage goes beyond the specific context mentioned above and refers to the more comprehensive framework of the use of nuclear energy and the problems of its ethical legitimisation.

As a general guideline the following principle applies for an ethical justification of the use of nuclear energy. Evidence must be provided as a matter of principle that the hazard potential linked with the use of nuclear energy can be minimised to such an extent that it is considered the lesser evil when compared with all the evils which would result from the renunciation of its use. The hazards linked to final storage and disposal represent only one part of the overall hazard potential to be minimised. In particular, it must be distinguished from the hazard potential linked to the direct operation of nuclear power plants. When considering this requirement, the question as to how the use of nuclear energy can be justified has to be asked at both hazard levels.

This, however, means that even if the hazard of a core meltdown accident with simultaneous release of hazardous substances can in principle be ruled out, the use of nuclear energy cannot be justified as long as the question of disposal of radioactive substances resulting from normal operation is not appropriately guaranteed.

This means, that due to prevailing conditions under which the peaceful use of nuclear energy cannot be stopped in the foreseeable future, the question of what is to be done with the radioactive waste must be solved in the immediate future.

Before I conclude, I should like to make a comment on the relationship between social acceptance and ethical legitimisation. Social acceptance results from a variety of reasons which may to some extent be of an ethical nature, but always comprises pre-ethical and sometimes even unethical motives. Public opinion, trends and fashions play as great a role as individual interests, moods and the personal and different stocks of factual knowledge and competency for assessment. It is therefore quite natural that the same matter meets with support in one society while it is rejected in another. For this reason, social convictions and ethical justifications must not be automatically equated since this would imply either reducing the question of morality to the question of acceptance or avoiding the question of acceptance by society by asking what can be justified on ethical grounds.

What makes dealing with the phenomenon of social consent and rejection so extremely difficult - and this is demonstrated most clearly by the pros and cons in society with regard to final storage of radioactive waste - largely depends on the fact that opponents usually believe themselves to be unfailably right. They claim the dogmatic truth of their stance and, therefore, make it a question of personal conscience. The result is that the conflicts that must be resolved inevitably lead to conflicts of conviction which, in general give no room for compromise.

Finally, the question must be asked as to whether our society is still at all prepared to enter the process of weighing the aspects of good and evil or whether the opposing fronts are so hardened already that a true discussion is no longer possible. Given the importance of this problem, however, we must, I believe, try once more to embark on this way and to resume the discussion.
Responsables aujourd’hui pour demain

M. Allègre
Président de l’Andra
Agence nationale pour la gestion des déchets radioactifs

Y. Quéré
Président du Conseil Scientifique de l’Andra

L’éthique a pour objet d’énoncer des principes qui puissent garantir les droits fondamentaux des hommes. Elle vise à conjurer l’instinctive priorité que donnent à leurs intérêts chaque homme, chaque groupe, chaque nation, aux dépens de tous les autres. En un mot elle essaie d’établir le plus d’équité possible dans une société.

Une règle morale impérieuse ...

Quoique la moralité diffère d’une civilisation à une autre, ou d’une époque à une autre, elle porte des caractères universels : on ne saurait nier que tous les hommes se rallient à quelques grandes prescriptions. L’une d’elles, la règle dite d’or, a le mérite de les résumer toutes en une formulation commune sur tous les continents : "ne fais pas à autrui ce que tu ne voudrais pas qu’on te fasse". Le message judéo-chrétien a insufflé à cette règle une force supplémentaire en proclamant "frères" tous les hommes, au nom d’un Dieu dont il les dit fils. Recevant ainsi l’appui de la transcendance, une règle d’abord pratique s’érige ainsi en absolu.

Quelle que soit la référence, laïque ou religieuse, de cette loi, nous en voyons les articles s’élargir au fur et à mesure que s’éloignent de notre champ de vision les hommes qu’elle désigne à notre sollicitude. Du clan au village, du village à la nation, de la nation à la planète, des devoirs nous sont intimés, de plus en plus abstraits puisque nous connaissions de moins en moins nos obligés. Chez les anciens déjà, on n’ignore pas le secours porté à l’inconnu : l’étranger, le voyageur, y sont l’objet de protection même s’ils ne paient pas de retour leur bienfaiteur. Cette aide fournie au tout venant, qu’illustre dans l’Évangile le récit du Bon Samaritain, est sans doute plus méritoire que les services rendus à des tout proches. Il est le signe que nous ramenons l’homme lointain dans notre proximité, que nous lui conférons la substance, les attributs et les privilèges d’un véritable frère.

... qu’il nous faut étendre ...

Mais voici que des nuisances durables que nous engendrons et laissons à d’autres en héritage nous invitent à introduire non plus seulement l’homme d’ailleurs mais l’homme du futur dans notre champ éthique et à l’y installer. Comment ne pas discerner ici ce que cette intrusion a de profondément inédit ? L’obligation, si noble en sol, d’hospitalité et de fraternité que nous venons d’évoquer était moins abstraite qu’il n’y paraissait. La rencontre d’homme à homme, entre contemporains, était toujours possible. Elle devient ici impensable. Aucune cordialité ne s’établira jamais entre des êtres que des siècles séparent. Nous voilà désormais confrontés à cette inquiétude sans précédent : la règle d’or jusqu’ici appliquée aux hommes d’ailleurs - si différents fussent-ils, au
moins étaient-ils contemporains et pouvaient-ils entrer en relation - en étendant son obligation aux hommes de demain nous prescrit des devoirs envers une humanité pour nous irrémédiablement sans visage.

Non que ce lien éthique qui nous relie à nos descendants lointains soit une idée neuve : il n’a sans doute pas existé un charpentier, un tailleur de pierre, qui aient bâti un pont sans méditer plus ou moins confusément sur leur responsabilité face aux hommes futurs qui, des siècles durant, franchiraient ce pont d’un pas confiant. Mais ce devoir éthique prend une extension singulièr en notre temps en raison de l’accroissement de notre capacité de nuisance, lequel affine notre sentiment de responsabilité vis-à-vis de nos descendants. Nous avons appris à tenir l’exploitation intensive des richesses de la planète pour un vol à leur détriment et de même l’accumulation des déchets de nos activités industrielles pour une iniquité à leur égard. Nous serions gravement coupables si nous négligions cet élargissement de l’éthique : par le biais des risques que nous leur imposons elle nous charge de devoirs spécifiques de frères aînés.

... à un avenir indéterminé

De surcroît, un domaine nouveau de l’activité humaine apparaît qui repousse à des distances inédites le champ temporel de l’éthique. Jusque là, les durées s’évaluaient en générations : “je veux laisser à mes arrière petits-neveux une Terre où il puissent vivre dans la paix et le bien-être". L’horizon de notre sollicitude nous laissait imaginer avec quelque vraisemblance les hommes du futur, nos enfants en somme, encore à notre image. Avec la gestion de nos déchets industriels apparaissent des durées radicalement autres : s’ils sont nucléaires, les "périodes" se comptent parfois en millénaires, voire en centaines de millénaires. S’ils sont chimiques, nous n’avons bien souvent même plus d’échelle disponible : les durées sont illimitées. Se trouve là mise en scène une humanité proprement inimaginable.

Des questions insolubles ...


... et cependant une certitude

Mais à quoi bon nous interroger sur cette humanité future vu l’impossibilité de répondre ? Discernons plutôt dans le stockage des déchets radioactifs de longue période, et plus généralement dans celui des déchets de l’industrie chimique, des sommations éthiques d’une ampleur imprévue. C’est elles que nous devons considérer : nous n’avons pas le droit de laisser des risques en héritage à des générations lointaines ; et nous ne pouvons pas esquer la question en postulant que les progrès scientifiques les préservent.

Certes nous nous devons en priorité à la sécurité et à la santé de nos contemporains. C’est à eux que nous devons d’abord appliquer notre éthique. Ce sont eux en premier lieu que nous devons protéger des résidus, s’ils sont nocifs, de nos activités industrielles. Mais au moins ces activités sont-elles les leurs. Bénéfiques, ils en profitent. Maléfiques, ils ont la possibilité de les combattre. En regard de quoi nous impliquons aujourd’hui par nos stockages d’innombrables générations futures totalement
non-responsables. Afin d’assurer un "développement durable" à nos descendants, nous devons leur transmettre notre savoir-faire technique sans rejeter sur eux la charge d’en assumer les nuisances, contrepartie des bénéfices que nous en avons nous-mêmes retirés. Parmi tant d’inconnus qui nous harcèlent, au moins avons-nous une certitude : que notre négligence nuira. Que nos conduites présentes ont acquis le redoutable pouvoir d’exercer des effets quasiment illimités dans le temps. Et la dimension du mal donne l’étendue de la vigilance requise.

Une peur stimulante ...

Soyons honnêtes. Sans doute notre génération n’aurait-elle pas tracé avec autant de fermeté cette "nouvelle frontière" de l’éthique si elle n’avait été aiguillonnée par la peur. Des accidents comme ceux de Bhopal pour le risque chimique, ou de Tchernobyl pour le nucléaire, ont inauguré une nouvelle méfiance envers les activités industrielles polluantes et leurs retombées immédiates mais aussi futures. L’écologie y a trouvé une justification supplémentaire à ses mises en garde, dénonçant, outre les nuisances humaines, les blessures portées à la Nature. Dans cette méfiance, salons ce qu’elle a de fondé, et donc de stimulant pour nos recherches sur la sécurité et l’environnement, mais sachons aussi démêler ce qu’elle peut avoir d’irrationnel et de subjectif.

Notons à ce sujet que bien d’autres risques (accidents d’avion, etc...) beaucoup plus tangibles sont parfaitement acceptés parce qu’intégrés dans le quotidien et donc banalisés. Comme le fait remarquer J.C. PETIT, le stockage de déchets radioactifs présente de nombreuses caractéristiques qui rendent malaisée son acceptabilité par le public. Relative nouveauté, manque de familiarité du grand public avec des questions techniquement aussi ardues, sentiment d’impuissance des populations proches, étalement dans le temps des effets nocifs éventuels, etc, sont autant de paramètres défavorables à cet égard. Ajoutons le pèché originel d’Hiroshima, les erreurs passées de communication, le comportement irresponsible de certains pays, et le caractère insidieux de l’irradiation.

... qui ne peut fonder une éthique

Quoi qu’il en soit sur les origines de la peur, ici sur son bien-fondé ou là sur sa déraison, ce n’est pas sur elle que peut se bâtir une réflexion éthique. La peur, démultipliée par la rumeur, ou les média, a été trop souvent un ressort de violences, d’intolérances ou d’intégrismes pour que l’on ne tente pas d’abord de l’analyser. Ainsi sera-t-on peut-être amenés à refléter la peur croissante des déchets à l’incontestable amélioration de conditions globales de fonctionnement des usines chimiques, ou à la relative banalisation des centrales nucléaires, un "transfert de peur" s’opérant d’objets qui semblent maîtrisés vers les résidus qu’ils produisent, et qui s’accumulent. Une semblable diabolisation des déchets nucléaires ne serait pas plus admissible qu’une présentation systématique lénifiante des problèmes à résoudre.

Un autre grand ressort des intolérances et des intégrismes est l’ignorance. L’éthique et la simple raison se rejoignent pour exiger que l’on veille avec un soin et une constance sans faille à la formation et à l’information du public, ainsi que de toutes les instances de décision.

Des principes valables pour tous les déchets ...

Il s’agit maintenant, à la lumière des quelques réflexions précédentes, de poser les principes qui doivent, à nos yeux, guider les recherches en matière de stockage des déchets.

La singularité des déchets radioactifs est beaucoup moins grande qu’on ne le croit généralement. En effet, l’approche ne devrait pas être fondamentalement différente pour un cylindre
de verre contenant des déchets de retraitement vieux de quelques centaines d’années, devenu un très faible émetteur bêta-gamma mais contenant des émetteurs alpha à vie très longue d’une part, et pour un déchet chimique toxique dont la durée de vie est "éternelle" d’autre part.

En revanche la formulation des problèmes, la recherche de solutions fiables et l'internalisation des coûts correspondants sont beaucoup plus avancées pour les déchets nucléaires que pour les autres.

Au delà du souci de protection de la santé humaine qui est à la base de toute éthique relative à la gestion de déchets de toute nature, quelques principes généraux valables pour tous types de déchets peuvent être dégagés :

1. **Le "déchet ultime" doit être minimisé en nocivité et en volume.**

Sans entrer dans la polémique "retraitement ou stockage direct", il est clair que l'industrie du retraitement fait en permanence de gros efforts pour réduire très sensiblement le volume des déchets conditionnés.

Pour la réduction de la nocivité, les études concernant la transmutation / incinération peuvent laisser espérer à long terme des résultats à condition de procéder à un retraitement poussé. Même en cas de succès de ces études, prévues par la loi de décembre 1991 et menées activement en France, on ne pourra pas tout transformer et le recours au stockage souterrain a toutes chances de demeurer nécessaire ; mais la nature des déchets à stocker en sera modifiée.

2. **Le producteur de déchets est le payeur.**

Ce principe est respecté pour les déchets nucléaires plus que partout ailleurs puisque cette industrie prévoit dès le départ d’inclure dans ses coûts des provisions correspondant au démantèlement final des installations et à la gestion des déchets.

3. **C’est la génération présente qui doit en premier lieu être protégée des nuisances**

Notre réflexion éthique concernant le futur ne doit en aucune façon nous faire négliger la protection due à nos contemporains.

4. **La génération qui engendre les produits polluants est responsable vis-à-vis des générations futures** au même titre que l’industriel pollueur est responsable vis à vis de son environnement proche.

Ce principe de responsabilité signifie qu’il appartient à la génération bénéficiaire de l’activité polluante de ne pas faire supporter à celles qui la suivront les nuisances ni le coût de la remise en ordre de la nature afin de proscrire tout risque "anormal" pour ces générations à venir.

Ceci revient à dire que dans toute entreprise l’homme doit laisser le lieu de son activité aussi "propre" lorsque cette activité se termine qu’il l’était au commencement. En termes plus imagés, le principe est "prêter de laisser la nature au moins aussi propre en partant qu’on l’a trouvée en arrivant" afin que l’homme futur dispose initialement pour son développement d’autant de chances que l’homme d’aujourd’hui.
C'est bien ainsi que devra s'effectuer le démantèlement des centrales nucléaires. La gestion des déchets au jour le jour devra être telle qu'elle permette in fine le respect strict de ce principe.

5. Solidarité

**Solidarité intergénération** puisque la gestion des déchets aujourd'hui doit permettre d’éviter les nuisances demain.

**Solidarité internationale** puisqu’il ne s’agit pas bien sûr de reporter les nuisances sur le voisin. L’extrême sensibilité de la question des déchets radioactifs et les abus commis par certains en exportant leur pollution sans précaution dans les pays sous-développés ont conduit à juste titre à admettre que chaque Etat doit s’occuper de ses propres déchets. Telle est du moins la loi française. Dans un avenir plus ou moins éloigné, à condition que toutes les précautions soient prises sur un plan international, aucun principe éthique fondamental ne devrait interdire à plusieurs pays de s’associer pour résoudre en commun le problème du stockage de leurs déchets radioactifs. Nous en sommes encore très loin mais une telle évolution n’est pas impensable dans la mesure où les progrès réalisés auront permis de donner toutes les garanties quant à l’absence de nocivité d’un tel stockage.

**Solidarité nationale** puisque l’ensemble des déchets produits sur le territoire seraient vraisemblablement stockés en un seul site. La population-hôte doit comme il est normal tirer avantage de l’accueil d’une activité industrielle sensible mais, cet avantage ne représente en aucun cas l’achat du silence devant un risque excessif.

6. Démocratie et ouverture

Les études et les choix doivent s’opérer par étapes dans le cadre d’un processus démocratique et ouvert assurant une large information-formation du public ainsi qu’une complète transparence, avec une difficulté tenant à l’importante technicité du domaine. Tel est le principe sur lequel repose la loi française de décembre 1991 pour les déchets radioactifs. Telle est aussi la raison d’être d’autorités de sûreté indépendantes.

... et quelques commentaires relatifs au secteur nucléaire

1. Un reproche est souvent formulé : il aurait fallu savoir exactement comment régler le problème des déchets radioactifs avant de lancer l’ensemble des opérations industrielles. La génération qui nous précède aurait-elle de ce fait contrévenu aux règles les plus élémentaires de l’éthique ? Comme le dit François Michelin, "lorsque l’on monte dans un train on aime bien savoir où il va".

Tout d’abord il est clair que dans une science nouvelle, les progrès des connaissances se réalisent en parallèle sur tous les fronts. On peut d’autant mieux démontrer la fiabilité d’un stockage que l’ensemble des connaissances scientifiques sur lesquelles on s’appuie est vaste.
D'autre part, le nucléaire a dès le début fait un effort important pour la gestion des déchets qui ont été très vite conditionnés sous une forme solide et depuis longtemps les experts internationaux considèrent le stockage géologique comme une solution possible à condition de l'étudier suffisamment à fond.

Aujourd'hui, en surface les centres de stockage pour déchets faiblement radioactifs sont opérationnels, ainsi que les entreposages pour les déchets haute activité. En ce qui concerne le stockage profond, nous sommes dans la phase des études appliquées.

2. **Certains calculs purement économiques**, comme par exemple ceux faits en matière de sécurité routière, introduisent une valeur chiffrée de la vie humaine. Une telle approche parait impossible dans notre domaine car le moindre coefficient d'actualisation, sans lequel il n'est pas de calcul économique, reviendrait à tenir pour négligeables les générations au-delà de quelques dizaines d'années, donc à se désintéresser totalement de leur sort.

3. **La démonstration de sûreté** est la caractéristique essentielle des stockages de déchets radioactifs. Elle présente trois traits originaux :

   - Elle est un préalable indispensable à toute autorisation. A ce titre, elle constitue même la garantie essentielle sur le plan de l'éthique.
   - La technique (colis et barrières ouvrées) et la nature elle-même (géologie), concourent toutes deux à réaliser le confinement des déchets, sans intervention ultérieure.
   - L'intervalle de temps à prendre en compte (cent mille, voire un million d'années) est d'une durée tout à fait inhabituelle.

Les déchets radioactifs les plus dangereux, les verres issus du retraitement (ou les combustibles irradiés) contiennent en mélange intime des produits de fission, très actifs mais à vie courte ou moyenne et des transuraniens, beaucoup moins actifs mais à vie très longue. On peut en déduire schématiquement que la sûreté d'un bon stockage repose :

   - pendant les premiers siècles (500 à 1000 ans) à la fois sur la qualité de la barrière ouvrée et de la barrière géologique pour confiner les éléments à très haute activité mais à vie courte ou moyenne
   - au delà, presque exclusivement sur la qualité de la barrière écologique pour le confinement des radionucléides émetteurs alpha à vie longue.

Dans la mesure où l'eau est le vecteur du transfert des radionucléides vers la biosphère, une barrière géologique sera d'autant meilleure que l'eau n'y circulera pas

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1 En France la vitrification des produits de fission a été étudiée dès 1960 et industrialisée au même rythme que le programme électro-nucléaire.

2 100 mille ans est une durée au-delà de l'entendement humain et pourtant si l'épaisseur d'une feuille de papier représente 100 mille ans, l'âge de la Terre correspond à une pile de feuilles de papier de 5 mètres de haut.
ou infiniment peu et que la mobilité-solubilité des radionuclides y sera négligeable. Ces deux paramètres sont essentiels pour qualifier un site de stockage profond.

La géoprospective, science qui essaye de prédire la vitesse de variation des évolutions géologiques futures à partir de l'étude du passé, permet de comprendre à quel point l'échelle des temps géologiques est différente de l'échelle du temps humain.

Les analogues naturels (par exemple piles naturelles d'Oklo au Gabon) montrent combien les transferts des radionuclides dans le sous-sol peuvent être dans certaines circonstances extraordinairement limités. D'autre part, les nombreux gisements d'hydrocarbures présents dans le monde sont là pour démontrer que la nature a su confiner pendant des dizaines ou des centaines de millions d'années, jusqu'à ce que l'homme les découvre, des substances beaucoup plus fugaces que les radionuclides.

4. Si l'on admet ce "devoir de faire de notre mieux" à l'égard des générations futures, ne leur ferait-on pas courir un moindre risque en laissant les déchets les plus dangereux en surface sous bonne garde ? Ce serait à bon compte décharger notre conscience autant que notre portefeuille. "Faire confiance à la science" qui réglera un jour le problème de la destruction des transuraniens et les laisser en surface en attendant serait faire un pari aussi incertain dans son issue que dans sa date de réalisation ; de plus la totalité du problème ne s'en trouverait pas pour autant régliée. Dans la mesure où un terme suffisamment précis et proche ne pourrait être fixé à un tel entreposage de surface, ce serait spéculer indûment sur l'avenir pour faire semblant de résoudre un problème actuel. Il est impossible de raisonner sur la continuité de l'ordre social et politique, partant sur le devenir des déchets radioactifs vie longue entreposés en surface, au delà de quelques siècles. Au contraire les stocker dans une formation géologique revient à les faire passer de l'échelle du temps présent à l'échelle des temps géologiques en bénéficiant de la pérennité et de la très faible variabilité que cette notion impose.

Quel que soit l'homme futur, le confinement géologique doit être choisi pour assurer un retour négligeable dans la biosphère. Il n'y a aucune difficulté à adopter pour l'homme d'après demain des normes identiques à celles - très basses - aujourd'hui admises dans la mesure où celles-ci s'inscrivent dans la variabilité de la radioactivité naturelle. En effet quelle que soit sa sensibilité aux radiations, l'homme futur devra toujours supporter la radioactivité naturelle.

5. Défausser totalement la responsabilité des choix sur les générations futures n'est pas acceptable. A l'inverse est-il conforme à l'éthique de figer - pour leur bien - tous les choix sans qu'elles aient la possibilité d'y revenir ? C'est le problème de la réversibilité du stockage souterrain.

Une certaine forme de réversibilité est sans doute possible et souhaitable au tout début de la vie d'un stockage souterrain. Pendant cette période, de l'ordre du siècle, on pourra vérifier de très près la validité des solutions techniques et être prêt à retirer éventuellement certains colis si les besoins de la recherche scientifique le justifient. De plus il n'y a sans doute pas de problème moral majeur à s'en remettre à la génération n + 2 ou n + 3 du soin de procéder à la fermeture d'un stockage, pour autant que tout ait été préparé par la génération n.
En revanche maintenir un stockage souterrain ouvert pendant une très longue durée (ce qui l'assimilait d'ailleurs à un entreposage de longue durée en surface) présenterait plus de risques - miniers et autres - que d'avantages et serait d'ailleurs en contradiction avec la notion même de sûreté à très long terme puisque le stockage ne pourrait de ce fait être considéré comme étanche.

Nous n'avons aucune idée de l'avenir de notre espèce :

- Ou bien nos lointains descendants auront régressé par rapport à nous et à ce moment là il vaut mieux avoir mis en oeuvre jusqu'au bout des solutions qui garantiront pleinement leur avenir.

- Ou bien ils seront nettement plus avancés que nous et alors ils n'auront aucune peine, tant que la mémoire du stockage sera conservée, à revenir s'ils le jugeut utile récupérer les déchets par des techniques minières appropriées. Une fois la mémoire perdue, et on ne peut pas supposer qu'elle ne le soit pas dans la longue période, on se trouvera ramené au cas précédent si le "gisement" de déchets est redécouvert par hasard car cela ne pourra être que par des descendants évolués.

Il faut bien reconnaître que la fermeture d'un stockage dans le souci de ne pas faire porter aux générations futures le poids de la gestion des déchets, présente aux yeux du public un inconvénient majeur ; elle est marquée du sceau de "l'irréparable". Mais (voir ci-dessus) l'irréversibilité n'est pas irrémédiable pour des descendants évolués et cette notion sera d'autant mieux acceptée que les scientifiques auront su démontrer, notamment par une expérimentation sérieuse dans des laboratoires souterrains, que le risque encouru dans le long terme est réellement négligeable. Attention toutefois à ne pas tomber dans l'excès inverse : des études trop longues, trop diversifiées et trop coûteuses pourraient amener le public à penser que le problème est tellement complexe qu'il est impossible de le résoudre !

6. Un stockage souterrain encourt le reproche de stériliser une partie de la nature.

Un stockage peut effectivement empêcher les générations futures d'exploiter des ressources minières situées dans son voisinage immédiat. Il est certain qu'il rend inaccessible pour longtemps un volume de sous-sol de l'ordre du kilomètre cube. Est-ce exceptionnel ? Toute activité humaine stérilise peu ou prou le lieu sur lequel elle s'exerce.

Sans faire appel à l'intervention de l'homme, les roches situées sous l'Antarctique sont totalement hors d'atteinte, et ce pour de nombreux millions d'années.

Si le lieu de stockage est convenablement choisi, de tels inconvénients sont réellement mineurs et ne paraissent en rien contraires à l'éthique.

En guise de conclusion

Nous avons rappelé comment de nouveaux problèmes éthiques émergent dès lors que nous incluons, dans notre sphère d'attention aux hommes et à la nature, les millénaires à venir. Si nos déchets industriels ont initialement suscité ces questions d'une manière globale et quelque peu
imprécise, ceux d'origine nucléaire ont eu ce "merite" pédagogique d'afficher des durées chiffrables et de poser les problèmes en termes clairs.

L'immensité de ces durées interdisant toute connaissance des hommes concernés par nos déchets et sujets de notre préoccupation, nous sommes réduits à poser ces principes éthiques simples et élémentaires - ce qui ne les rend que plus contraignants - en amont de nos travaux de recherche sur le stockage de ces déchets.

S'agissant de déchets nucléaires, outre le stockage de surface pour les parties les moins radioactives, il apparaît actuellement qu'un stockage géologique profond bien conçu doit pouvoir être particulièrement respectueux de ces principes. Cette solution a une très haute probabilité de se révéler indispensable. L'éthique nous commande de l'étudier à fond et sans attendre, tout en menant activement des études sur les autres voies de recherche. Ne rien faire et s'en remettre exclusivement à des hypothétiques améliorations drastiques à venir serait en revanche commettre un véritable "péché d'indifférence" et agir contrairement à l'éthique.

Une fois cette direction prise, la grande majorité des questions soulevées apparaîtront sans doute d'une importance toute relative et ne devront pas constituer des freins à l'action.

L'éthique personnelle du gestionnaire de déchets radioactifs consiste alors à réunir le maximum d'éléments afin de s'assurer qu'une combinaison adéquate de la géologie et de la technologie permet de démontrer l'absence de nocivité d'un stockage souterrain, aussi bien à court-moyen terme qu'à très long terme. Ainsi, ce gestionnaire devra-t-il acquérir l'intime conviction que la solution proposée n'entraînera pas de risque de radiotoxicité pour les générations actuelles et futures, ou tout au moins pas plus que celui résultant des phénomènes naturels. Une telle solidarité dans le temps (inter-générations) et dans l'espace (dépassant les frontières politiques) n'est-elle pas le fondement même de l'éthique tel que rappelé plus haut ?

L'objectif ultime est de contribuer à ce que le "nuclear world" ne soit pas demain comme certains le disent un "new killer world" mais au contraire un "new clear world".

En s'engageant à fond dans l'étude d'un projet de cette importance, en prenant tout le temps nécessaire, en travaillant avec un maximum de sérieux et de compétence, en acquérant finalement l'intime conviction que la solution proposée sera valable aussi bien pour les générations présentes que futures, en étendant enfin suffisamment convaincants pour faire partager cette intime conviction aussi bien à l'autorité de sûreté qu'au grand public, les responsables des études de stockage souterrain donneront tout son sens à la formule d'Albert Camus : "la vraie générosité envers l'avenir consiste à tout donner au présent". Ce faisant, ils auront le sentiment d'avoir agi conformément à l'éthique.

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3 Comme la loi de décembre 1991 l'impose en France.
Managing Today for Tomorrow

M. Allègre
Chairman of the Board, Andra
Agence nationale pour la gestion des déchets radioactifs

Y. Quéré
Chairman of the Scientific Advisory Board, Andra

(Translation)

The purpose of ethics is to set forth principles that can guarantee basic human rights. Ethics attempts to repress the priority instinctively given by each individual, each group, each nation to its own interests to the detriment of all others. In a word, ethics is an attempt to establish as much equity as possible in a society.

An imperative moral rule...

Although morality differs from one civilization to another or from one era to another, it has universal characteristics. One cannot deny that all men rally around a few major prescriptions. One of them, the so-called Golden Rule, has the advantage of summing them all up in an expression known on all continents: "Do unto others as you would have them do unto you." Judeo-Christian doctrine breathed added force into this rule by proclaiming that all men are the sons of a God and therefore "brothers". Thus armed with transcendence, a rule that was above all practical was given the force of an absolute.

Regardless of whether the reference is secular or religious, we are seeing a widening of its applicability, even as the men that it commends to our solicitude retreat from our field of vision. From the clan to the village, from the village to the nation, from the nation to the planet, the duties conveyed to us become increasingly abstract because we are increasingly unfamiliar with the recipients of our grace. We know of the assistance given to the unknown man in ancient societies: the foreigner, the traveller is protected even if he does not return the favour to his benefactor. This succour given to all and sundry illustrated in the Evangel by the story of the Good Samaritan is doubtless more meritorious than services rendered to our close ones. It is the sign that we bring those who are distant into our midst, that we given them the substance, attributes and privileges of true brothers.

...we must expand...

But now the long-term harmful effects that we generate and leave as an inheritance for others prompt us to introduce not just the man from elsewhere but the man of the future into our ethical field of vision and to ensconce him there. How can one fail to recognize that this intrusion is profoundly unprecedented? The obligation just described, so inherently noble, to provide hospitality and fraternity was less abstract than it appeared. The meeting of contemporaries, one man to another, was still possible. In this scenario it becomes unthinkable. No cordiality will ever reign between beings centuries apart. Henceforth, we find ourselves confronted with the unprecedented anxiety: expanding
the Golden Rule to include men of the future obliges us towards hopelessly faceless human beings, whereas it previously applied to outsiders who, as different as they might be, were at least contemporary and capable of communicating with us.

Not that this ethical tie that links us to our remote descendants is a new idea: doubtlessly, the carpenter or stone cutter never existed who built a bridge without somewhat vaguely meditating on his responsibility to future men who will cross this bridge with a confident step for centuries to come. But this ethical duty takes on a unique dimension in our time due to our increased capacity for harm, sharpening our sense of responsibility for our descendants. We have learned to regard the intensive mining of the planet's riches as pillage to our descendants' detriment and the accumulation of waste from our industrial activities as flagrant injustice in their regard. We would be guilty of gross negligence not to heed the widening of the ethic; with the risks that we subject them to come the special duties of elder brothers.

...to the indefinite future

Furthermore, a new field of human activity that pushes the time scale of the ethic to unprecedented lengths is appearing on the scene. Before, time frames were quantified in terms of generations: "I want to leave my great nephews an Earth where they can live in peace and well being." The horizon of our solicitude allowed us to picture future men, our children, somewhat plausibly in our own image. With industrial waste management came radically different time frames: if the waste is nuclear, "half lives" are sometimes counted in thousands or even hundreds of thousands of years. If the waste is chemical, we often no longer have an available frame of reference: the time scales are unlimited. Then, human beings who are totally unimaginable to us enter the scene.

Questions without answers...

Now we are asked to take into consideration the peace and well being of human beings whose customs, knowledge and rapport with nature we cannot even imagine. Will they be supermen, through natural or artificial evolution? Or will dreadful cataclysms return them to the caveman state? Will they be able to decipher our messages? Will they have any awareness of their distant ancestors? Does it even make sense to try to penetrate the mists of time to ponder their situation?

...yet a certainty remains

Given the impossibility of finding answers, what purpose is served by asking ourselves questions about future humankind? Let us instead see in the disposal of long-lived radioactive waste, and more broadly in the disposal of the waste from the chemical industry, an ethical command of unforeseen magnitude. It is this injunction that we must consider: we have no right to leave behind a heritage of risks for generations in the distant future, and we cannot dodge the issue by postulating that scientific progress will protect them.

Certainly, our first responsibility is the health and safety of our contemporaries. We must apply our ethic to them first and foremost. We must protect them above all from any harmful byproducts of our industrial activities. But at least these activities are conducted for them. They profit from their beneficial effects. They can combat their harmful effects. For this, we are effecting untold numbers of future generations by the repositories we create today, for which they are totally unresponsible. To ensure our descendants' "sustainable development", we must give them our technical know-how without making them assume the responsibility for dealing with the harmful effects accompanying the benefits that we ourselves have gained. Among all the unknowns that torment us, at least one
certainty remains: that our negligence will cause harm. That our present behaviours have acquired the formidable power of exercising influences that are practically unending in time. The magnitude of the harm sets the tone for the breadth of the vigilance required.

Driving fear...

Let's be honest. Our generation would probably not have mapped out this "new ethical frontier" so unwaveringly had it not been driven by fear. Accidents such as those of Bhopal in the chemical field or of Chernobyl in the nuclear field unveiled a new mistrust of industrial operations that generate pollution and of their fallout now as well as in the future. In these accidents, the field of ecology found added justifcation for its warnings, denouncing the woundng of nature as much as the harmful effects to man. In this mistrust, let us salute the part of it that is well-founded and that therefore spurs our research on safety and environmental protection, but let us also know how to sort out what is irrational and subjective in it.

In this regard, let us note that many other much more tangible risks—airplane crashes, etc.—are completely accepted because they are part of daily life and therefore commonplace. As J.C. Petit notes, radioactive waste disposal has several characteristics that make public acceptance uncomfortable. Its relative newness, the public's lack of familiarity with such complex technical issues, the affected community's feeling of powerlessness, the long-term duration of potential harmful effects, etc. are just some of the unfavourable parameters in this regard. To this let us add the "original sin" represented by Hiroshima, mistakes made in the past in communicating, the irresponsible behaviour of certain countries and the invisibility of irradiation.

...cannot pave the way for an ethic

Regardless of where the fear came from or whether it is well-founded or irrational, it cannot serve as a foundation for ethical reasoning. Fear, fuelled by rumour or by the media, has been a springboard for violence, intolerance or reactionary behaviour too often to not attempt to analyze it first. In doing this, one might conclude that the growing fear of waste is connected to the fact that overall operating conditions have improved at chemical plants or that nuclear power plants are now relatively commonplace, and that the fear has been transferred from objects that appear to be under control to the growing amounts of byproducts they produce. This "demonization" of nuclear waste is no more acceptable than a systematically soothing presentation of the problems to be resolved.

Another big springboard for intolerance and reactionary behaviour is lack of knowledge. Ethics and simple reason converge in requiring that unrelenting care and perseverance be given to informing and educating the public as well as to any entity involved in the decision-making process.

Principles applicable to all waste...

In light of the foregoing, it is now time to set forth the principles that should, in our opinion, inform waste disposal research.

Radioactive waste is much less unique than generally believed. In fact, the approach for a canister of several hundred year old vitrified reprocessing waste containing very long-lived alpha emitters but that has become a very low beta-gamma emitter should not be fundamentally different from the approach to a toxic chemical waste whose life is "eternal".
Yet the formulation of the issues, the search for reliable solutions and the assumption of the corresponding costs are much further along for nuclear waste than for other waste types.

Beyond the concern for protecting the human environment that is the foundation of any ethic pertaining to any type of waste management, a few general principles applicable to all waste types can be discerned:

1. The harmfulness and volume of "final waste" must be minimized.

Without entering into the "reprocessing or direct disposal" debate, it is clear that the reprocessing industry constantly expends considerable effort to reduce solidified waste volumes substantially.

To reduce harmful effects, transmutation/incineration studies underway in France as mandated by the Waste Act of December 1991 give rise to hope for long term results on the condition that advanced reprocessing is undertaken. Even if these studies are successful, not everything can be transformed. There is therefore every likelihood that an underground repository will continue to be a necessity, but the type of waste requiring disposal will have been changed.

2. The waste generator pays.

This principle is followed for nuclear waste more than for any other, since the nuclear industry includes reserves in its operating budgets for facility dismantling and waste management from the very start.

3. The generation of today must be protected from harm first.

Our ethical deliberations about the future must not cause us to neglect the protection we owe our contemporaries in any way.

4. The generation that produces the pollution is responsible for future generations, just as the industrial polluter is responsible for the surrounding environment.

What this principle of responsibility means is that the generation benefiting from the polluting activity is responsible for preventing subsequent generations from suffering either the harmful effects or the costs associated with reestablishing the natural order to protect themselves from any "abnormal" risk.

This amounts to saying that any human activity must leave the area where it was exercised as "clean" when the activity ceases as it was in the beginning. In other words, "please leave nature at least as clean when you leave as you found it when you arrived" so that future man begins with as many opportunities for prosperity as present day man.

This is indeed how nuclear power plants should be dismantled. Waste should be managed on a daily basis in a manner that makes strict compliance with this principle ultimately achievable.

5. Fellowship

Intergenerational fellowship, since how waste is managed today must allow the harmful effects of tomorrow to be avoided.
International fellowship, since it is obviously not a matter of transferring the harmful effects to one's neighbour. The highly sensitive nature of the radioactive waste issue and the abuses committed by some in exporting their pollution to underdeveloped nations without taking the necessary precautions rightly resulted in the recognition that each nation must take care of its own waste. At least, French law recognizes this. In a more or less distant future, and assuming that the necessary precautions are taken on the international level, there is no fundamental ethical principle that prevents countries from joining together to resolve their radioactive waste disposal problems. We are a long way away from this, but such a development is not unthinkable as long as the resulting repository program has provided the necessary guarantees relative to the absence of noxiousness.

National fellowship, since all waste generated domestically would likely be disposed of at a single site. It is perfectly normal that the host community should gain certain benefits from hosting a sensitive industrial activity, but these benefits should under no circumstances be viewed as buying their silence in the face of excessive risk.

6. Democracy and Accessibility

Disposal studies and decisions must occur in stages in the framework of a democratic and open process that provides widespread public information and education and ensures complete openness, with all the difficulties implied by the highly technical nature of the subject matter. This is the principle on which the French Radioactive Waste Act of December 1991 reposes. This is also the fundamental mission of the independent regulatory authorities.

...and a few remarks on the nuclear sector

1. One criticism is often formulated: the radioactive waste issue should have been settled before beginning industrial operations. In so doing, did the generation before us transgress the most elementary rules of ethics? As François Michelin said, "when one gets on a train one likes to know where it is going."

First of all, when it comes to a new science, knowledge is gained on all fronts simultaneously. The wider the body of scientific knowledge from which to draw, the easier it is to demonstrate the reliability of a repository.

Furthermore, the nuclear field expended considerable effort on waste management from the beginning, quickly processed it into solid form¹, and international experts have long considered geologic disposal to be a potential solution as long as it is studied in enough detail.

Today, disposal facilities for low-level radioactive waste are in operation at the surface, as are storage facilities for high-level waste. We are in the applied research phase with regard to deep disposal.

2. Certain purely economic assessments, such as those pertaining to highway safety, put a quantitative value on human life. This type of approach does not seem feasible for our field, because the very designation of a present value, without which there can be no economic

¹ In France, vitrification of fission products was examined as early as 1960 and commercialized at the same pace as the nuclear power program.
assessment, would amount to discounting the relevance of generations several decades hence, and therefore to being totally unmoved by their fate.

3. The **demonstration of safety** is an essential aspect of radioactive waste repositories with three unique characteristics:

   - it is a prerequisite for a license. In this respect, it actually constitutes the principal guarantee on an ethical level.

   - The technology (waste package and engineered barriers) and nature itself (geology) work together to create the waste containment system without active maintenance.

   - The time interval to be taken into consideration (one hundred thousand or even one million years) is a completely unprecedented time frame. The most hazardous radioactive waste—vitrified reprocessing waste or spent fuel—contains a mixture of short- or medium-lived but highly active fission products and less active, very long-lived transuranics. To simplify, one can deduce that the safety of a good repository rests:

     - on the ability of both the engineered barrier and the geologic barrier to contain very high-level but short- or medium-lived elements for the first few centuries (500 to 1000 years);

     - on the ability of the geologic barrier acting alone to contain long-lived alpha-emitting radioactive waste thereafter.

Insofar as **water** is the vector for radionuclide transport to the biosphere, the less the water flow (from zero to an infinitesimally small amount) and the lower the mobility-solubility of radionuclides, the better the geologic barrier. These two parameters are essential in the characterization of a deep disposal site.

Geoforecasting, a science that attempts to predict the rate of future geologic change based on study of the past, makes it possible to identify at what point the geologic time scale diverges from the human time scale.

Natural analogues, such as the natural Oklo reactors in Gabon, show how extraordinarily limited radionuclide transport in the ground may be under certain circumstances. In addition, the numerous deposits of hydrocarbons in existence around the world show that nature knew how to confine much more evanescent substances than radionuclides for tens or hundreds of millions of years before they were discovered by man.

4. If one accepts this "duty to do our best" in regard to **future generations**, wouldn't we be lessening their risks by keeping the most hazardous waste at the surface under heavy guard? It would be a cheap way to unload our consciences along with our wallets. "Leave it to science" to find a way to destroy the transuranics some day and keep them at the surface in the meantime would be a gamble as uncertain in its outcome as in its schedule of accomplishment, yet this would still not resolve the overall problem. Since it is not possible to establish a sufficiently definite and early time frame for this type of surface storage, this amounts to speculating on the future in order to appear to be solving the current problem. One cannot reason on the continuity of the social and political order, and therefore of the

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2 One hundred thousand years is a time frame beyond human comprehension and yet, if the thickness of a sheet of paper represents 100 thousand years, the age of the Earth corresponds to a pile of paper 5 meters high.
future of long-lived radioactive waste in surface storage, beyond a few centuries. Conversely, disposing of such waste in a geologic formation shifts the matter from the current time scale to geological time scales and requires that concepts of perpetuity and very low variability be brought into play.

No matter what the man of the future may be, the chosen method of geologic containment must ensure that transport to the biosphere is insignificant. Adopting standards for the man of the distant future which are identical to the very low ones accepted today raises no difficulty as long as they are inscribed within the variability of natural radioactivity. After all, regardless of his sensibilities regarding radiation, future man should still be able to tolerate natural radioactivity.

5. It is not acceptable to discard the decision-making responsibility completely for future generations to take up. Inversely, is it consistent with the ethic to have all decisions written in stone—for the good of those future generations—without leaving them the possibility of changing them? Herein lies the retrievability issue of deep disposal.

A certain form of retrievability is undoubtedly possible and desirable in the very beginning of the life of a deep repository. During this time period of about one century, one could verify the validity of technical approaches at close proximity and possibly be prepared to recover certain waste packages if warranted by the requirements of scientific research. Leaving repository closure to generation n+2 or n+3 probably doesn't raise any major moral issues, as long as everything has been prepared in advance by generation n.

Conversely, keeping a deep repository open for a very long period of time (which would make it more closely resemble a long-term surface storage facility) would present more risks—mining and otherwise—than benefits. Furthermore, it would be inconsistent with the very concept of long-term safety, since the repository could hardly be considered watertight if it is left open.

We know nothing about the future of our species:

• either our far away descendants will have regressed in relation to us, in which case it is better to have gone all the way in implementing approaches that fully guarantee their future safety;

• or they will be much more advanced than us, in which case they will have no difficulty in recovering the waste with appropriate mining techniques if deemed necessary, as long as the memory of the repository has been preserved. This still applies even if that memory is lost—and one cannot assume otherwise over the very long term—and the waste "deposit" is discovered by chance, for this could only occur with highly advanced descendants.

It must be admitted that closing a repository so that future generations do not bear the burden of waste management is a major drawback in the eyes of the public; it bears the stamp of "irremediable". But non-retrievability is not irreversible for highly advanced descendants, as discussed above. The more scientists succeed in demonstrating that the risk incurred over the long term is truly insignificant, particularly through responsible experimentation in underground laboratories, the better this concept will be accepted. However, one must avoid falling into the reverse extreme: research that lasts too long, is too diversified and costs too much could make the public think that the issue is so complex that it cannot be resolved!
6. A deep repository draws the accusation that it renders a portion of nature unusable.

A repository may indeed prevent future generations from mining natural resources in its immediate vicinity, and there is no doubt that it makes an approximately one cubic kilometre area of the host rock inaccessible for a long time. Is this so unusual? All human activities render their work sites more or less unusable for other purposes.

Without human intervention, the formations beneath the Antarctic ice cap would be completely out of reach, and for many millions of years at that.

If the repository location is suitably chosen, such drawbacks are truly minor and are in no way inconsistent with ethics.

By way of conclusion

We have reviewed how new ethical issues emerge whenever thousand year time frames enter into our sphere of attention to man and nature. While these questions were initially prompted by industrial waste in a general and rather non-specific way, those of nuclear origin had the educational "merit" of involving quantifiable periods of time and of presenting the issues in clear-cut terms.

Because the immensity of the time periods involved preclude any knowledge about the subjects of our concern, the future human beings who will be affected by our waste, we can only present simple, elementary, and thereby much more restrictive ethical principles as we begin our research into the disposal of this waste.

In the matter of nuclear waste, aside from surface disposal of its less radioactive components, it currently appears that a well-designed deep geologic repository would be particularly conducive to compliance with these principles. This approach has a very high probably of turning out to be unavoidable. Ethics require us to examine it in detail and without delay, while actively pursuing studies in the other research areas\(^3\). Conversely, to do nothing and to rely exclusively on major but hypothetical improvements to come would be to commit a real "sin of indifference" and to act unethically.

Once this decision is made, the vast majority of questions raised will undoubtedly show themselves to be of only relative importance and should not be allowed to interfere with progress.

Personal ethics dictate that the radioactive waste manager assemble as much information as possible to demonstrate that the deep repository presents no harmful effects in the short to mid term as well as over the very long term through a balanced combination of geology and technology. This manager must therefore be deeply convinced that the proposed solution will not result in a risk of radiotoxicity to current or future generations, or at least no more than that resulting from natural phenomena. Isn't this fellowship in time (intergenerationally) and in space (beyond political borders) the very foundation of ethics as we have defined it?

The ultimate goal for the nuclear community is to make tomorrow's world not the "strange new world", as some would have it, but rather a "clean new world". By fully committing to the study of a project of this importance, by taking as much time as necessary, by working with the utmost professionalism and skill, by ultimately acquiring the conviction that the recommended solution will be as valid for future generations as it is for those of the present, and lastly by being persuasive enough to make regulatory authorities and the public alike share this conviction, those responsible for deep disposal research will give meaning to Albert Camus's formula, "real generosity towards the future consists of giving everything to the present." In so doing, they will know that they have acted ethically.

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3 As required in France by the Waste Act of December 1991.
Cost Benefit Analysis, Sustainability and Long-lived Radioactive Waste Management

Frans Berkhout
Science Policy Research Unit
University of Sussex
United Kingdom

Introduction

Following the 1992 Rio conference, the concept of sustainability has been placed at the core of environmental policy all around the world. Fundamentally it is an appeal for long-term environmental burdens caused by current human and industrial activities to be reduced to a bare minimum. It is motivated by the fear that these activities may severely affect the future habitability of the planet and therefore the scope of future societies to develop. Although an idea with obvious appeal, sustainability has proven extremely difficult to make operational. For radioactive waste management, an environmental problem for which long-term perspectives have always been regarded as important, sustainability may be an applicable concept.

Cost-benefit analysis is a technique originally developed for the economic appraisal of capital investment projects. In cost-benefit analysis all costs and benefits are given a money value. Typically costs and benefits do not occur at the same time - capital expenditure usually coming some time before the benefits of revenues and profits. Taking account of the changing value of money through time, cost-benefit analysis ‘discounts’ costs and benefits to bring them all to a ‘present value’. For instance, at a 9 percent discount rate, something which will be worth £1.09 in a year’s time has a present value of £1. Having given present values to all the costs and benefits associated with a project, its total net benefit can be calculated and compared against other projects.

The notion of discounting has come to be used across a wide range of other problems, including resource management and environmental policy, in which the benefits and costs of a policy occur over time. Increasingly, discounting has been applied to the assessment of radioactive waste and nuclear decommissioning strategy.

The objective of this paper is to examine how far the sustainability concept and the technique of cost-benefit analysis (CBA) can be applied to the problem of radioactive waste management. The paper begins with a slightly altered definition of the problem to the one carried in the NEA’s background document (NEA, 1994). A preliminary attempt is then be made to ascribe burdens to the various phases of long-lived radioactive waste management. The appropriateness of CBA and the sustainability concept for making decisions about long-term waste management policy is then discussed. We end with some conclusions about the appropriateness of systematic assessment approaches in the political process of constructing social consent for technological decisions.
The Problem

Radioactive wastes have been regarded as presenting special management problems since the 1930s. This, together with the physical fact that the primary hazard of these materials (ionising radiation) declines naturally through radioactive decay, has encouraged nuclear planners to seek to impose comprehensive engineered and institutional controls over radioactive wastes. Most high-level wastes have therefore been stored under surveillance, only a small proportion having been disposed of to the environment.

However, there has long been a recognition that this practice is unsustainable in the long-term. First, populations living around storage sites want to be assured that their regions will not become dumping grounds for radioactive wastes. Second, long-term storage imposes a duty of care and the costs of future technological intervention on future generations. Third, storage assumes that future societies will always be in a position to exercise institutional control over these materials. Recent revelations of nuclear weapons material smuggling in Europe demonstrate again that this assumption is unfounded. Fourth, radioactive waste management is an activity which generally provides no net benefit, but only costs. The beneficiaries of waste production live now, in the future waste management will incur only costs.¹

For these reasons it has become policy in most countries that present generations must set in place options for the final disposal of high-level wastes. It is widely accepted that the most appropriate means of achieving this is to bury them deep underground. The central policy problem is that while present societies must prepare for the day when final disposal becomes fact, they are aware that they will always be faced with some residual uncertainty about the safety of the repository. They are also aware that by disposing of wastes in the short-term they would be foreclosing possibly better options which might be developed in the future. The balance which must therefore be struck is between the benefits to future societies of being free of the burdens of maintaining institutional control, and the costs of uncertainty over safety, and the costs of foreclosure.

Overcoming opposition and building social consensus is likely to take a long time, and final disposal is not likely to begin anywhere for several decades. Even then, there is likely to be a prolonged period over which the repository is monitored and the option of retrievability or repair is maintained. Any decision to end direct control over high-level wastes is therefore still several generations away in most countries. This imposes financial, political and physical burdens on people and societies in the nearer future.

Our inability to forecast precisely the behaviour of repositories also means that we must accept that radioactive wastes cannot be entirely excluded from the biosphere. Long-term safety assessments have to assume that some fraction of the radioactivity eventually will be released into the human environment over long periods of time. Releases of radioactivity to the biosphere can therefore be expected, and these will be translated into radiation doses to humans and other biota.

Defining Wastes, and Costs and Benefits

To simplify matters, the present assessment will be limited to the problem of how to deal with radioactive wastes. The costs and benefits to be considered are therefore those associated with different waste management strategies, rather than a wider assessment including the entire nuclear fuel cycle. The analysis presented here will not be concerned with how to balance the benefits of

¹ It may be argued that if the high-level waste is in the form of spent fuel, some future benefit may be produced through the recycling of plutonium.
nuclear power against the long-term risks of radioactive waste management. Nor will it be concerned with trying to compare the risks of the nuclear fuel cycle with those of other electricity generation systems.

In looking at waste disposal strategies we are concerned with two types of radioactive waste: spent nuclear fuel, and high-level waste (HLW) generated from the reprocessing of spent fuel.\(^2\) Spent fuel is a metal or a ceramic containing a substantial proportion of uranium and plutonium and needing to be monitored by international inspectors. HLW will primarily be encapsulated in a glass, contains primarily fission products and other transuranic elements, and generally falls outside safeguards. Most of the world’s high-level waste will be stored and disposed of as spent fuel. No more than one-quarter is likely, on current estimates, to be in the form of reprocessing wastes (Albright et al., 1993).

Because of their differing characteristics, the two waste forms will impose differing burdens on future generations. For instance, whereas it is assumed that reprocessing high-level waste will be processed into a glass form soon after reprocessing, spent fuel is not expected to be encapsulated until shortly before final disposal. The costs of HLW vitrification will be borne now, the costs of spent fuel encapsulation will be borne perhaps 50 years hence.

While much attention is rightly given to the financial and health risks of radioactive waste management, there are a number of other burdens which must be considered. These relate mainly to the scientific, industrial and regulatory infrastructures which have grown around the whole nuclear enterprise, and which determine so many of its activities. Over long time periods, when great social and political changes can be expected, the preservation of such infrastructures cannot be assumed. The cost of maintaining these structures, unacknowledged today because we assume that they are justified by the benefits of nuclear energy, may prove to be a burden to future generations.

Nuclear waste policy decisions must therefore take into account many factors. A comprehensive list of these might include: the costs of waste management (financial burdens); the labour inputs of waste management (physical burdens); the risks to the health (burdens); the need to create and maintain regulatory agencies (institutional burdens); the need to resolve political conflict over waste policy (political burdens); and the need to prevent the theft and diversion of nuclear-weapons materials (security burdens).

Management of both spent fuel and HLW is likely to go through a number of phases, and in each of these phases different burdens will be invoked. For several decades at least, the waste will be stored. The primary reason for storage is to permit the decay of heat and radioactivity of the waste. Although there is a natural preference to avoid the handling of radioactive wastes unless for pressing safety reasons, a number of different storage technologies are available, and each will have somewhat different consequences for costs and risks to present and future populations.

Storage may continue for a very extended period, either by design or by circumstance. HLW began to be produced at Windscale in 1951. On past experience, it seems likely that this material will still be in store at the site in 2051. Dutch policy to 'isolate, control, monitor' highly toxic wastes (including radioactive waste) explicitly rejects disposition strategies which eliminate the opportunity for future human intervention. In this case, an explicit policy of monitored retrievable storage of HLW is therefore proposed.

In most countries, however, declared policy is to pursue final disposal. According to the currently accepted concept, this implies the construction and operation of geological repositories. Typically such repositories would be located on the territory of the country where the wastes originated,

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\(^2\) Following the work of the United States National Academy of Sciences, a third alternative of waste forms embedded with plutonium extracted from dismantled nuclear warheads has been proposed (USNAS, 1994).
although international repositories have also been considered. Under a final disposal policy, a decision would eventually need to be taken to seal the repository, although some surveillance might be maintained. A repository with spent fuel waste would probably need to continue to be subject to international verification, even after closure. Some commentators have been concerned that with heat and radioactive decay, a spent fuel repository would become a ‘plutonium mine’ which would be an attractive source of nuclear weapons material for a proliferating state.

Each stage of the management process produces a differing set of burdens. Table 1 provides a simple allocation of the burdens listed above to the different stages of high-level waste and spent fuel waste management - the darker the shading, the further into the future the burden. It is important to note that the nature of each of these burdens will be different depending on the waste type being considered. As we have seen, the costs of vitrifying reprocessed HLW will be borne in the short term, while those for spent fuel encapsulation would be borne much later. To take another example, since the heat rate from spent fuel is higher than from HLW, spent fuel may need to be stored for longer in order to conform with heat rate specifications than HLW.

Cost Benefit Analysis and Radioactive Waste Management

Cost benefit analysis is a technique for resolving resource allocation problems. Its main function has been in calculating the net economic benefit of different investment decisions. As explained above, discounting is the main device for giving commensurable valuations to costs and benefits which are not simultaneous.

There are two primary motivations behind discounting future streams of expected costs and benefits. The first is the existence of time preference: the preference for current over future consumption. The second, familiar in business practice, is the opportunity cost of capital: that resources invested now are likely to be productive in the future. Despite many problems of measurement, it is widely agreed that time preference rates will be below opportunity cost rates, and that social rates will be lower than private. This is because while private individuals will be certain of their own deaths and are therefore indifferent about long-term benefits, governments or societies at large will behave as if life continued indefinitely and must therefore be less myopic (Lind, 1982). The discount rate chosen will therefore depend on the problem being analysed.

A simple example where cost benefit analysis works well is the problem of whether a family household should install double-glazed windows. The up front costs and the future benefits in terms of energy savings are reasonably well known. Their monetary values are discounted over a relatively short period of time, and the bearer of the cost and the beneficiary are usually the same person or persons.

CBA has come to be widely applied to public policy issues, including problems of long-term resource conservation and depletion. Such applications have generated a long debate over whether to apply low or high discount rates to slow growing resources (forests) and environmental assets (biodiversity). On the one hand, high discount rates discourage the long term management of these resources, on the other hand, high discount rates also discourage capital investment which may be the main cause of environmental transformation or resource extraction. Low discount rates, while valuing environmental assets more highly would also encourage greater capital investment with possibly adverse environmental effects.

To overcome this paradox, economists concerned with environmental degradation have argued for a dual approach in which market discount rates are applied, but that projects are also be appraised according to a 'sustainability constraint' (see, Pearce, Markandya and Barbier, 1989). A sustainability constraint would involve devising a 'shadow project' which would parallel any environmentally-
damaging activity. For instance, proposals have been made for the planting of tree plantations to compensate for the emission of carbon to the atmosphere from fossil fuel power stations. A sustainability constraint applied to radioactive waste management would appear to argue for early final disposal since there is no obvious shadow project that could compensate for the long-term leaching of fission products into deep aquifers.

The welfare of future generations has also been considered in the cost benefit literature (see, Stiglitz, 1974, Solow, 1974 and Krutilla and Fisher, 1975), but has typically been treated as a special problem requiring a social discount rate to be set which provides for a more equitable distribution of welfare between the generations. The question of which rate to set is left unresolved, and where very long periods of time are involved, it appears to be unresolvable.

The obvious concern is that with positive discounting over long periods, the interests of future generations appear to be neglected. If one considers monetary costs alone, it is clear that even using a very low discount rate (2 percent is the rate used for the most secure form of investment, gifts) the present value of any project more than a couple of generations in the future will be reduced to an insignificant figure, and can therefore be ignored. Environmental clean up costing £1 today, which must be borne in 150 years time, discounted at a two percent discount rate, would have a present value of 5p.

This immediate concern is buttressed by ethical, theoretical and empirical arguments against applying discounting to intergenerational transfers of resources and environmental burdens. The ethical argument is that an instrument for efficiently allocating resources in the near term is an inadequate framework for considering the interests of future, unborn generations. Sen (1982) argues that there is '...very little scope for avoiding a deliberate ethical choice in choosing appropriate rates of discount'. This appears to be especially apparent in long-lived radioactive waste management where the benefits accrue only to the present generation, while future generations bear only the cost. Through discounting we are assuming that the burden of waste management will be less onerous for future generations than for us, and undervaluing their rights to be free of it entirely.

Theoretical support for the argument against discounting across generations also exists. Cost benefit analysis takes the existing distribution of resources as a given. Different distributions of resources produce different prices, including different discount rates. Since the distribution of resources will be changed by transfers of resources between generations, so will the discount rate. Playing with the discount rate to produce a desirable distribution of resources is therefore an illogical and inefficient procedure (Norgaard and Howarth, 1991). Norgaard and Howarth argue that where one is concerned with distributional issues, one is primarily dealing with problems of equity, and such problems should be resolved through political processes, not buried in arguments about which discount rate may be appropriate.

Recent debates about regional and global environmental justice demonstrate that distributive equity in risk management are becoming more, rather than less important. The core issue here is that environmental burdens should not be borne by communities which have not benefited from the economic activity which generated the burden. Although, in principle and in economic theory, such inequities can be redressed through compensation, in reality such compensation schemes may be of rather limited value.

Lastly there is an empirical argument. During the heyday of CBA in the 1950s and 1960s, an assumption of sustainable positive economic growth seemed reasonable. That is no longer the case. Having seen growth rates in industrialised countries decline and being more aware of the environmental limits to growth, our vision of the future has changed. A wide range of opinion still exists, but in general there has been a shift from being 'cornucopian' to being rather more 'pessimistic' about the future. The extrapolation of positive economic growth into the future therefore seems less
responsible today, and consequently the application of discounting over long time periods appears less legitimate.

The application of discounting directly to non-monetary costs, even over short periods, encounters further objections. How would one set a discount rate for the risk of death due to exposure to radiation? Since individuals are impatient and unsure about the future, they may be able to judge that they prefer life today over life tomorrow, that is, they can discount over their own future lives. But the idea of imposing discount rates over the lives of other people, let alone on an almost infinite set of succeeding generations seems extremely problematic.

Clearly resource allocation decisions are continually being made which imply mortal risks to human health. Many investment decisions are informed by cost benefit analyses which apply monetary values to life and apply discounting to these values (British road safety investment is closely driven by cost benefit assessments where the chief benefit is lives saved). However, such applications of cost-benefit analysis can rarely be decisive and have typically proven extremely controversial. This is primarily because such decisions involve larger, more complex technological systems with many different attributes affecting several different stakeholder groups. These attributes are typically incommensurable (as are the attributes in Table 1) and cannot be captured within a single, monetary value. The money valuation of human life or of a church spire has become a sophisticated art, but it remains a very imperfect means of informing what are essentially political decisions.

More importantly, the social distribution of the costs and benefits of a project or policy are nearly always uneven. The beneficiaries of a private investment are usually not the ones who bear the environmental or other burdens associated with a project. Attempts are typically made to redress this by either changing the discount rate to reflect equity considerations, or by referring to other criteria besides net benefit under CBA. The objective of efficiency thereby becomes tempered by objectives of equity. As we have seen, there is no unambiguous way of deciding on the 'right' discount rate in such cases, so that the result of such an analysis risks being seen as arbitrary from some perspectives.

This problem of distributional equity becomes even more acute where cost benefit analysis is extended beyond currently living people. In particular it is not possible to foresee the preferences of future societies. For instance, what kinds of safety standards will societies 100 years hence insist on when they construct HLW stores or spent fuel repositories? Will the dread of radiation still be as pervasive as it is today? Will future societies be more capable of developing a social consensus over final disposal policy? Will the diversion or theft of nuclear material be regarded as more or less of a threat?

Where monetary costs and benefits are concerned, the problem of intergenerational equity may be resolved by assuming economic growth. In applying discounting an assumption is made that because of increasing wealth, the relative monetary values of most things decline (antiques and unique ecosystems are counterexamples). As the economy grows and general welfare improves, so the value of any given benefit declines relatively. Benefits projected further into the future will have less value, relatively, than those expected in the near future.

But such 'growth' concepts cannot be readily applied to non-monetary costs and benefits. Does the value of the risk of death decline over time? For radioactive wastes there is the in-built reduction of risk with time due to the decay of radioactivity. In this sense discounting is already a central feature of radioactive waste management. It might also be argued that, with improved scientific understanding, cancer will one day be curable, and that therefore over the longer term the risk of a cancer-related death could be discounted. An opposite view would hold that with increased wealth, tolerance of health risks falls and that improved monitoring technology leads to greater concern about environmental risks - witness the recent episode of public concern over air pollution levels in Britain.
We have moved in the present discussion from simple short-term investment decisions to a range of long-term problems of public policy in which a variety of incommensurable and unevenly distributed costs and benefits are at issue, many of which are not well known. The larger the problem, the more we are faced with uncertainty and with problems of distributional equity. And as the problem of distributional equity has loomed larger, so the appropriateness of cost-benefit analysis has become more arguable.

In terms of scale and scope, most aspects of the long-term management of radioactive waste fall in the latter category. Referring again to Table 1, the only set of burdens to which CBA could confidently be applied would be economic assessments of different interim storage strategies for HLW or spent fuel. Such stores would have relatively well-defined costs and benefits, and would have a lifetime of about a generation (30 years).

All the other problems invoke issues of intergenerational equity, or issues which cannot be adequately handled within cost benefit analysis. As we have argued, problems of equity cannot be fitted within a formal procedure designed to secure the efficient distribution of resources. Hence, CBA cannot unambiguously be applied to any of the other problems of radioactive waste management policy, even though it may have some function in placing in context the key decisions over intra- and intergenerational equity which need to be resolved.

Sustainability and Radioactive Waste Management

The sustainability concept can be seen as a response to the inadequacies of cost benefit analysis. Its perspective is over the long-term, and its main appeal is that it is concerned with problems of intergenerational effects. Sustainability is not a relative concept, but seeks to set some absolute rules. In contrast to cost benefit assessment, it is therefore not concerned with allocating costs and benefits according to criteria of efficiency. Nor is it at root concerned with setting rules about social or intergenerational equity. Rather, it is concerned with minimising the transfer of direct or indirect burdens across generations. The basic rule is that irreducible burdens (usually environmental) on future generations should be minimised. It therefore appears to impose more stringent constraints on current activities than would cost benefit assessment. Nonetheless, 'sustainability' still faces the infeasible task of accounting for the preferences of future generations since it seeks to secure "...the ability of future generations to meet their own needs." What their 'ability' and what their 'needs' will be remains as unclear as ever.

The sustainability concept has come to be associated with two other principles. The first is the 'precautionary principle' which is defined as "preparedness to take precautionary actions where there are good grounds for judging either that action taken promptly at comparatively low cost may avoid more costly damage later, or that irreversible effects may follow if action is delayed." The second is the 'polluter pays principle' under which the full costs of controlling or cleaning up pollution are borne by those causing it.

The precautionary principle suggests that early action to mitigate environmental effects is preferred, and that irreversible effects should be avoided altogether. Loss of biodiversity is the best example of this, but effects which are not 'repairable' through human effort, or reversible through natural process would also be included - wide-scale radioactive pollution would, in most cases, be regarded as an irreversible environmental effect.

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3 The Brundtland Commission definition is "development which meets the needs of the present without compromising the ability of future generations to meet their own needs."
The 'polluter pays principle' is primarily concerned with the monetary costs of pollution control. The most straightforward interpretation of the principle is that if pollution and its various direct and indirect effects are not fully dealt with by those who caused it, funds should be endowed to those who are given the task. Where intergenerational transfers of funds are concerned, as in long-term radioactive waste management, there are two main considerations. First that conservative assumptions are made about the future growth of funds, and second that some account is taken of the real inflation which has affected most nuclear industry-related technologies. Significant contingencies therefore need to be built into waste management funds.

Over periods longer than a couple of generations, and in line with the sustainability concept, the polluter pays principle suggests a cautious approach that would not pre-empt future decisions. Such an approach would assume no discounting of costs beyond a certain point, i.e. after the closure of the reactor or other activity which gave rise to the radioactive waste, and would estimate costs on the basis of early disposal to a repository. If net positive economic growth did occur, and the estimation of costs had been correct, then a surplus might be left to those who dealt with the wastes (Thomas, Mackerron and Surrey, 1994). Since sustainability does not require an equalisation of burdens between generations, the balance of economic risk should be skewed towards the current generation.

As we have argued, the sustainability concept appears to be appropriate to radioactive waste policy, but the result is not obvious. On the issue of whether to store or to dispose, no clear guidance appears to be given. On the one hand it seems clear that most of the burdens of waste management would be reduced to a minimum with early final disposal of wastes to a geological repository. In addition, early disposal would ensure that the financial burden of waste management was borne by current or near future generations. On the other hand, by some definitions the final disposal of highly-toxic wastes is an irreversible environmental change, and should be avoided. No decision on relinquishing human control is possible because this would be a pre-emption of the choice of future generations to manage wastes in the way they chose. A decision now also runs the risk of jeopardising access to as yet unexploited resources.

Under a storage strategy what conditions would be commensurate with sustainability? The minimisation of burdens would probably involve emplacing radioactive wastes in a passively safe facility where monitoring and repair of waste containers was automated. Long-term safety criteria for such a facility could be set according to current criteria, or employing a ‘risk-added’ approach (Goodin, 1983), or according to some tougher standard which would take into account future tightening of standards. Under the risk-added approach, current best practice is applied universally. For instance, the cumulative health risk associated with the storage facility should be comparable to the cumulative health risk to all future generations associated with the final disposal in a geological repository of the wastes. For advocates of this strategy, the minimisation of burdens would not come through improved safety, but in the assurance that if something went wrong, it could be put right. To gain this type of assurance industrial, regulatory and security infrastructures would need to be maintained, although probably at a lower level than at current radioactive waste storage sites.

What can sustainability suggest for a strategy of waste disposal? If the presumption is for early disposal, then the first question is - how early? The key physical criterion here is the heat output of the waste, since to a large degree this determines the design of the repository. The earlier the waste is placed underground, the larger the repository will have to be and the lower will be the certainty that the safety assessment for the repository is reliable. Over a 30-year period the heat output from a standard PWR fuel assembly will have decayed to about 1000 watts/tonne (Wt) of fuel (down from about 10,000 Wt after one year). The decay of heat output then slows dramatically, so that after 100 years the output is still at 500 Wt. The marginal benefits of waiting for further decay

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to reduce the size of the repository, or improve assurance about repository safety therefore decline sharply after about a generation. This is especially so for HLW which has a lower heat rate, primarily due to the extraction of plutonium and its daughters.

Under sustainability guidelines, safety criteria for a repository might also be based on a risk-added concept. For instance, the health risks associated with a repository might be made comparable to the cumulative risks to all future generations associated with the uranium which generated the wastes, had it been left unmined. A more stringent approach would, as above, attempt to take into account future increased risk aversion. This could be done by taking current standards and adding a further degree of contingency, by for instance improving current radiological objectives by an order of magnitude. The problem of jeopardising future resource extraction appears to be a rather minor one, considering the actual scale of repositories, but could be avoided through foresight studies of mineral resources in the region of a repository.

Financing of the repository project would need to be covered by a levy on nuclear electricity and its deposition in segregated and highly secure funds. A regular review would be made of the estimated costs of the repository system and adjustments made to the levy accordingly.

What we end up with under sustainability guidelines closely resembles many existing policies for radioactive waste management: early disposal under stringent safety criteria and financed out of current nuclear electricity consumption. But while this is the stated objective, there must be grave doubts about whether the objective is achievable. The main reason for this is the inability in many countries to overcome the bitter political conflict which geological repository projects provoke. Although it is possible that new breeds of technological dread will lead to a reduced level of concern in the future, so far as we can see today, the fear of radiation will always be with us. If sustainability guidelines suggest that disposal is the right strategy, its main force may be in putting renewed pressure on the nuclear industry and governments to find a way of achieving public acceptance for repository projects early. As we have argued, the main burdens being placed on future generations through delay are social and political.

Conclusions

We have argued that no assessment methodology, no matter how systematic, can take account of all the ethical and distributional problems thrown up by long-lived radioactive waste management. Rather than depending on a single technique, it is necessary to stress the process of achieving public acceptance of a management strategy, whether it is storage or disposal. The role of systematic assessment is in laying out the main parameters of the problem and to predict what the ramifications of different strategies might be - not to come to a conclusion about which is best. That decision is a political one, and must be left to political processes. What matters is who makes the final decisions and by what authority. In the 'risk society' of today, in which our trust is tied to abstract systems of authority, rather than to individuals or to what can be experienced, the achievement of trust is especially difficult. Logical and comprehensive assessments of the consequences of different courses of action may play a part in achieving that trust, but they should not be used as a means of burying or ignoring the ethical choices which are being made.
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Table 1. **Burdens associated with long-term radioactive waste management**

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<th>Storage</th>
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<td>Security</td>
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<td><strong>Long-term storage</strong></td>
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<td>Physical</td>
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<td>Health (workers)</td>
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<td>Institutional</td>
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<td><strong>Final disposal</strong></td>
<td>Building repository</td>
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<td>Political</td>
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<td>Repository post-closure</td>
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<td>Health (other populations)</td>
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Dr. Flowers

When you say that in your opinion the political burden will be greater than the physical and health burdens on future generations, does this mean that if you were able to convert the political burden into money, it would show a larger money cost to society than building repositories and monitoring and so on?

Mr. Berkhout

I am not sure that I want to engage in a debate about these monetary costs. For me, the political conflicts around this question have been extremely damaging. In Sweden, for instance, two governments were, in the late 1970s, overthrown because of this question. There have been demonstrations, there have been countless meetings where people argue and where mistrust is generated. Mistrust which, in a rather haphazard way, infects many other kinds of technological and political decisions. In that sense it is a sort of cancer which needs to be cured because it has these very malign effects which cannot be properly judged or quantified.

Mr. Bernero

The U.S. has experience with low-level waste sites that demonstrates a quantitative answer to your question. The developmental and institutional costs of low-level radioactive waste sites far exceed the costs to actually build and operate the sites, and we do not have them yet.
Balancing Risks and Benefits Fairly Across Generations:
Cost/Benefit Considerations

Bayard L. Catron
George Washington University
(United States)

Introduction

This paper has been prepared for the OECD Nuclear Energy Agency Workshop on the
Environmental and Ethical Aspects of Long-Lived Radioactive Waste Disposal. The Workshop is
intended as a step toward preparation of a collective opinion on deep geological storage of nuclear
waste. As requested, this paper addresses the specific questions raised in the Background Document.
Since I was asked to focus on the cost/benefit considerations, the paper is organized around those
eight questions. Views on the other ethics questions are expressed in the Appendix.

The ethical concerns here involve the circumstances and extent of imposing risks and burdens
on unwitting, involuntary populations and related issues— for example, the distribution of burdens and
benefits on different populations ("environmental justice"), and the relative importance of social values
such as safety and principles such as preserving options for future generations. Technical issues like
comparing the physical features of possible waste storage sites can often be addressed without asking
larger questions. In contrast, dealing with ethical issues characteristically involves asking the larger
questions: What should societies be doing to reduce risks to current and future populations (e.g., by
exploring alternative types of energy production)? What steps should be taken (e.g., research) to
compensate future generations for non-renewable resource use and environmental health/safety
burdens? Who should decide (and how) which groups should bear what risks?

While it is understandable that this workshop will not address such wide-ranging issues as
public participation and reducing waste generation, these can be key elements of ethical responses
to environmental risks. Also, appropriate ethical principles can rarely be applied simply and often must
be balanced against each other. Thus, an ethical analysis should not be expected to provide definitive
recommendations on such issues as isolating wastes on-site versus in geological repositories, or the
choice of temporary/retrievable versus permanent storage.

Ideas in this paper have grown out of a study for which I am research director, entitled Deciding for the
Future: Balancing Risks and Benefits Fairly Across Generations. The project, conducted by the National
Academy of Public Administration (an organization chartered by Congress to improve government at all levels),
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Cost/Benefit Considerations

a. Discounting of costs with time is a widely applied technique in the evaluation of the impact of economic and industrial decisions. Could or should discounting of long-term health risks due to radioactive waste disposal be envisaged?

While the technique of discounting is specifically designed to make trade-offs between the present and the future, it is problematic when comparisons involve the lives and health of future, unborn people. Indeed, there is broad agreement in the literature [limited here to the literature available in English] that, for various reasons, it is inappropriate to use traditional discounting techniques over long periods of time, especially for projects that affect multiple generations. In a conference on discounting issues held in 1988, Lind¹ stated that, "for long term policies, the benefit-cost rationale for discounting breaks down and must be reestablished on principles incorporating intergenerational equity." In an overview of the same conference, Charles W. Howe², then President of the Association of Environmental and Resource Economists, concluded that "a defensible philosophical basis for long term, intergenerational discounting has yet to be found."

One reason the technique does not work well is simple mathematics: since the present value of future benefits declines the farther out into the future they occur, even with a very low discount rate, a health benefit saving thousands of lives 10,000 years from now would have a negligible present value. To illustrate this point dramatically, "a complete loss of the world's GNP a hundred years from now would be worth about one million dollars today if discounted by the present prime rate."³

But beyond this, there are several substantive arguments that discounting is not ethically appropriate for decisions that affect future generations. Mishan⁴ argues against discounting benefits to future generations at all, since they accrue to different individuals. Norgaard and Howarth⁵ argue that "discounting is appropriate with respect to the efficient use of this generation's resources but it inappropriate when this generation is primarily concerned with redistributing resource rights to future generations." According to a similar argument, discounting "...is designed to help assess only whether an action is efficient, not whether it is equitable. ...Discounting for environmental regulations that span several generations may obscure intergenerational inequities."⁶

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The U.S. Environmental Protection Agency (EPA)\(^7\) has described three arguments against discounting future health risks in particular. First, some argue that no discount rate should be used because there is no actual life-saving market mechanism that can value society's benefits from future versus present lives saved.

Second, discounting can lead to inequitable distribution of health benefits: "When using a 10 percent discount rate, for example, we value 100 lives saved 30 years in the future the same as 6 lives saved in the present. Thus, when a high discount rate is used, expenditures made to save lives in the future appear to be much less effective than expenditures that will save lives today."

Third, it may be inappropriate to use the same discount factor for money and for human life. The argument here is that, while the value of money varies with time, the value of human life does not. Raiffa, Schwartz and Weinstein\(^8\) strongly disagree, arguing that discounting is:

...merely an accounting device to place the dollars spent and the lives saved at the same point in time. In effect, we discount future lives precisely because dollars invested today should be expected to yield more life-saving in the future than in the present. It is because of our concern that resources be applied at the point in time where they can save the most lives that we "discount" lives. It is, emphatically, not because we wish to value future lives less than we value present lives in any absolute or utilitarian sense. It is because we do not want to be wasteful of scarce resources in saving lives, either present or future.

Without agreed-on methods of handling intergenerational benefits and costs, long-term projects cannot be effectively defended or compared adequately to present ones. For example, Richard Howarth\(^9\) states that "we can reasonably speculate that society would be willing to spend extra resources to mitigate the threat of potentially catastrophic risks. But the appropriate sum to pay is beyond the reach of economic analysis and thus depends on the exercise of raw value judgements regarding what is acceptable and what is not." And d'Arge and Spash\(^10\) argue that: "Because of classical and new problems in valuing public goods, it is currently impossible to quantitatively estimate the amount of optimal compensation [to future generations for environmental damage caused by the present generation]."

Given all these arguments, we are left with a need to make decisions that involve balancing risks and benefits between present and future generations without agreed-on, definitive analytic tools. In the absence of general agreement on how future generations should be treated, no comprehensive treatment of long-term discounting can be developed. A stronger philosophical foundation regarding the equitable treatment of future generations seems to be necessary before adequate discounting techniques can be developed.

However, this is not the end of the matter. Despite the lack of an adequate technique, decisions affecting future generations still must be made-- and we do frequently discount the future

\(^7\) Ibid.


In fact, even when no technique or rate is explicitly used. For example, in all those many situations when current decisions have long-range implications that are not taken into account, the long-term future is effectively discounted at the rate of 100 percent. [Also, when a discount rate is applied over a 20 or 30 year period, longer-term effects are typically totally ignored.] This amounts to a bias in favour of the present. On the other hand, it also seems at least intuitively irrational not to discount the future at all. For example, when the U.S. Department of Energy is not permitted to discount in setting priorities for its clean-up efforts, it must treat hypothetical risks 10,000 years in the future exactly like explicit current concrete risks, such as the risk to workers conducting clean-up activities.

In the absence of a viable and defensible discounting technique, other strategies can provide some guidance (though not "definitive solutions") to decision makers. First, a set of principles to "balance" the interests of present and future generations can help to make these trade-offs. Some principles are suggested under d.2) below, and discussed further in section f. Another strategy that recognizes the limitations of our ability to "balance" between present and future because of vast uncertainty about the far future is to focus on what we pass on to the next generation; this is discussed in section d.2) in relation to the sustainability ethic and the notion of a "rolling present."

b. Is it possible to assess what is passed on to future generations in terms of health risks, other detriments and possible benefits of all sorts, directly or indirectly? Should such an assessment be applied generically to human activities in a broad sense or should it concern only waste disposal issues?

Clearly, assessment should specifically address waste disposal and also the next "higher" level of analysis, waste generation. But broader comparisons are crucial as well, to assure that major resource allocations are not seriously imbalanced, and to assure that important social values are being served. [NOTE: Precise and definitive results should not be expected from the latter kind of analysis. We pass on a heritage to future generations, not just a bundle of risks and benefits; no analytic calculations can do justice to that.] Here, as with any important, complex public problem, multiple analyses and different levels of analysis are warranted.

c. How can the immediate needs of the current generations, for example for energy generation or public health protection, be balanced with intergenerational equity requirements in the very long term? This question is addressed in further detail by the next ones.

How can we balance risks and benefits fairly across generations, especially over the very long term? While other sections contain more detailed responses, the general outline of an answer to this question is as follows:

- The usual technique for making temporal comparisons, discounting, does not work well over long time frames-- and yet there is a continuing and increasing need to make trade-offs between current and future generations.

- Some principles have been developed that, with further iteration, can help in clarifying issues of ethics and fairness in making trade-offs between generations. These principles (sustainability, the precautionary principle, etc., discussed below) can help to guide decision making while not promising optimal solutions.

- Attempts to understand what is on the "very long term" side of the balance between present and future (for example through computer modelling) are confounded by vast uncertainty of various types. Our limited capacity to conceptualize the far future, much
less to act with it clearly in mind, necessitates a simpler method of decision making that doesn't rely on the "balancing" of interests over the very long term.

- For most practical purposes, decision making will continue to be incremental in nature, building on the sustainability ethic and using concepts like the "rolling present" (described below). However, the ethical dangers here-- such as rationalizing our self-interested preference for the present over the future-- should be appreciated. And when our actions will have significant impacts on future generations, as with nuclear waste management decisions, we should continue to do our best to see the implications empathically, from their point of view.

d. Are resources devoted to assuring safety of radioactive waste disposal appropriately balanced with risks, given that these resources could be applied to other societal goals? This question directly relates to achieving an appropriate balance between securing the resources needed to meet current needs, on the one hand, and conserving resources and protecting the environment to meet the needs of future generations, on the other hand. It is also related to the question of "how safe is safe enough" in a given area, and to the management of other risks which need to be kept under control as well.... Are there principles and decision-making processes which could be used to determine where resources should be applied?

There are two questions here-- the question of "appropriate balance", and the question of available principles and processes to govern resource allocation decisions.

d.1) The question of "appropriate balance" is crucial to both efficiency and equity. When money spent on risk reduction in one area would have higher payoffs if applied to reducing other risks, it may be (although is not necessarily) both inefficient and inequitable.

First, with respect to efficiency, when an increment of risk reduction of one sort requires greater expenditure than a similar increment of another, allocating funds to the latter buys more protection per unit of cost. Risk reduction requirements in the U.S. are notoriously variable: In one area, we will spend many millions of dollars per life saved, while in another only a few thousand dollars. While such variability is easy to criticize as irrational, it is important to bear in mind that many factors enter into the perception of the importance of a risk beyond the probability and magnitude of an event. For example, a risk that is imposed by human decisions is more likely to be perceived as requiring mitigation than "acts of God" or risks that people take on voluntarily. The question of "appropriate balance" therefore requires more than comparative risk assessment which, however important, should only be used to aid in decision making, not dictate it.

From an ethical point of view, it is not sufficient to demonstrate that alternative uses of money would theoretically be more efficient or effective in reducing risks. Rather, it may be necessary to show that reprogramming of resources can be accomplished and will in fact provide greater protection over time. [Note that "current unmet needs" can always be cited; this should not be allowed as a blanket rationalization for ignoring future generations. Also, "appropriate

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11 This variability is captured in a revealing table from the FY 1992 U.S. Budget, Table C-2, Part 2, p. 370. The Table portrays the risks and cost-effectiveness of over 50 health/safety regulations, comparing them specifically on the "cost-per-premature-death-averted." These costs range from a low of $.1 million for regulations like auto passive restraint/seat belt standards (adopted in 1984) to extremely high cost items like the hazardous waste disposal ban (1988; $4,190 million) and the proposed municipal solid waste landfill standards (1988; $19,107 million). The highest cost regulation, the hazardous waste listing for wood-preserving chemicals (1990), is $5,700,000 million per premature death averted! [This Table is also cited in a Breaking the Vicious Circle: Toward Effective Risk Regulation, by Stephen Breyer, the judge recently named to the U.S. Supreme Court by President Clinton.]
balance" in expenditures is not the only relevant ethical consideration; there is an elementary principle that we expect six-year-old children to understand: "If you make a mess that hurts other people, you should clean it up."

Moreover, there may be ethical limits on applying these resources to other societal goals—even other, more effective risk reduction efforts—because the particular people whose lives will be protected are not the same and the original hazard would be ignored. The mere fact that a greater number of other lives are at risk as a result of other initiatives is not a sufficient reason by itself to conclude that expenditures are inappropriately balanced. Thus, for example, if it is inefficient for the U.S. Department of Energy to spend $6 billion per year on high-level nuclear waste clean-up, perhaps those funds should not simply be reprogrammed to more efficient uses in general. An ethical alternative might be to explicitly reprogram them to reduce long-term risks of radiation exposure—for example to reduce the amount of nuclear waste generated, and to invest in recycling it, as the Dutch proposal described in the Background Document would require.

d.2) Turning to second question, first "principles" and then "decision-making processes" are discussed. Several caveats are necessary regarding the following set of proposed principles: First, they are provisional, tentative and need to be debated further. Second, in general they should be viewed in relation to each other and not in isolation, since some tend to favor the present over the future and others the reverse. Third, they are stated quite generally, and require further iteration to provide operational guidance to decision makers. Fourth, it would be a mistake to expect that any set of principles, no matter how fully iterated, can ever be definitive in giving optimal answers; it is the role of principles like these to be an aid to judgement, not a substitute for judgement. Fifth, they are not claimed to be "original"; this set was developed at a recent NAPA/DOE/Battelle workshop, but they are similar or identical to principles stated in the literature. [Note that NAPA has not yet taken any action with respect to these principles; they have not been endorsed, or recommended to the Department of Energy.]

**Proposed Intergenerational Equity Principles**

No generation should [needlessly] deprive its successors of the opportunity to enjoy a quality of life equivalent to its own.

1) Every generation is the trustee for those that follow.

2) There is an obligation to protect future generations provided the interests of the present generation and its immediate offspring are not jeopardized.

3) Near-term concrete hazards have priority over long-term hypothetical hazards.

4) However, this preference for the present and the near future is reduced where questions of irreversable harm are concerned.

5) When an action poses a plausible threat of catastrophic effects, then that action should not be pursued absent some significant countervailing need.

6) The reduction of resource stocks entails a duty to develop substitutes.

The overarching principle here may be recognized as a version of the "sustainability" ethic, a concept that has received wide-spread attention in the past decade since the World Commission on Environment and Development (popularly known as the Brundtland Commission)
was established by the United Nations. While more than 60 definitions have been enumerated, the best-known is that of the Brundtland Commission: sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." [This definition also probably enjoys wider acceptance than any other; for example, it was recently adopted in the U.S. by the President's Council on Sustainable Development.]

Note, however, that the current statement is phrased as an "equal opportunity" principle in a way that the Brundtland Commission version is not. Moreover, the notion of an opportunity for an "equivalent" quality of life is also not part of the earlier definition. In both of these ways, this statement of the principle appears to be more stringent than the Brundtland statement.

The word "needlessly," bracketed in the overarching principle, reflects a fundamental point of disagreement whether living generations are ethically permitted under any circumstances to knowingly deprive those yet unborn of equal opportunity. Some believe that no circumstances would warrant intentional serious degradation of the future quality of life, while others believe that, under some circumstances, the quality of current life takes priority. So this principle acknowledges a strong obligation to the future while the word "needlessly" maintains some undefined latitude to favour the present. [Similarly, there is underlying disagreement about the implications of the sustainability ethic for economic growth and limitations on the use of private property. In the U.S. at least, there has not yet been a willingness to confront these issues in the public discourse.]

Principle 1 helps to identify the nature of the relationship between present and future generations. There are various examples of the trustee concept in U.S. public policy. [Of course other countries could provide many illustrations as well, and often over a far longer period of time.] In some cases, it is written into law (e.g., the National Environmental Policy Act), while in many others it is implicitly present. But it is most apparent in U.S. history in the debate about settling aside public lands and the establishment of the National Park system. The analogy here with the use in law of the concept of "trustee" as an instrument for preserving value for others is not perfect, and some people prefer the use of "stewardship." But the point of the principle is to fix responsibility in the present for the implications and consequences of present actions on future generations.

The recent literature on intergenerational equity, which overwhelmingly supports the notion that we do have ethical obligations to the future, also overwhelmingly (though not unanimously) opposes making trade-offs favouring the future that fail to meet crucial obligations to present generations, or that impose an injustice on the present. Principle 2 recognizes both of these, while putting emphasis on "interests" of the present. It might be argued that, as stated, this principle provides too convenient a rationalization for the current generation to pursue its own narrow self-interest. A great deal hinges on the definition of "interests" in the principle: If interpreted broadly, the principle could be invoked to justify much greedy and wasteful behaviour. If defined narrowly, only "vital interests" or "basic needs" of the present could be used to justify not satisfying the obligations toward future generations. Given that self-interest is a very strong and pervasive motive, a narrower interpretation seems desirable to provide ethical protection against rationalization. The workshop suggested some operational guidelines to aid in making decisions and setting priorities:

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• Emphasize protecting present and near-future generations by: 1) addressing the highest near-term risk first; 2) giving additional priority if high long-term risks are also involved; and 3) seeking to minimize long-term risk consistent with the principles for intergenerational equity.

• Recognize and respond to the obligation to protect distant future generations, but do not do so at the expense of current and near-future generations. [If this provision is to have any force, "expense" cannot just mean "monetary costs," but something like "significant sacrifice."]

The next three principles (3, 4, and 5) are discussed under section f. below. Principle 6 addresses resource depletion; while not as relevant to environment safety and health, the underlying notion of an obligation to provide compensation is quite relevant.

Turning to the question of "decision processes," in the U.S. perhaps more than in most countries, a "process" concept of justice tends to prevail: If certain processes are followed, the resultant outcomes-- decisions, risk distribution, etc.-- are presumed to be just or fair. This is true not only formally (for example, "due process" as embodied in the U.S. Constitution), but is deeply imbedded in the popular mind. For example, "democratic values" are often defined in terms of processes-- voting, majority rule, etc. This accounts in part for the considerable attention paid to citizen ("stakeholder") participation in the decision process, to the question of who decides and how, and to the means of holding various parties to account their actions. [When various stakeholders are in bitter and intractable conflict and there is deep mistrust between them, paralysis can result, illustrating the limitations of this process orientation toward justice.]

Given our limitations in balancing current needs against those of the far future, such as the vast uncertainty of the latter, we need a simpler decision process. The sustainability concept tends to focus on passing on to the next generation a world with "equal opportunity" to enjoy a quality of life equivalent to ours, or a generation that is as "able to meet its own needs" as ours is. Sustainable development practices eliminate the need to second-guess the specific needs and desires of others who will come after us. Since we cannot predict into the distant future either the potential harm or the benefits of specific environmental practices, we can best act by providing for posterity what we ourselves have been provided, and by preserving options for them.

According to the idea of the "rolling present", the current generation has a responsibility to provide the next succeeding generation the skills, resources, and opportunities to deal with any problems the current generation passes on. Likewise, the next generation is obliged to do the same for the generation that follows it, and so on. In this way, future generations are given consideration and compensated for any harms passed on by the previous one. The rolling present concept includes an iterative decision process: Succeeding generations reevaluate the policies of the past using new information and their own values and priorities, and make appropriate policy changes. [Note that the concept behind this process, together with the principle of not foreclosing options for the future (see #2 in the Appendix), support temporary/retrievable storage as opposed to permanent storage of highly toxic wastes.]

This "rolling present" process has the advantage of being familiar, incremental, and easy to implement, but it also has some limitations and deficiencies. One deficiency is that it tends to ignore "time bombs"-- that is, risks that do not threaten immediate generations, but will affect later generations (for example, nuclear wastes that remain isolated for several generations and then contaminate ground water). More generally, this decision process can be criticized for making it too easy for the current generation to ignore the long-term implications of its actions. Even as we use this incremental process to make current decisions, we should perhaps be admonished to develop and refine our capacity and that of the next generation to consider empathically the welfare of future generations.
Is it preferable to take all physical actions today to minimize any bequest of liabilities for waste management actions to future generations. If not, how should financial assets be set aside to meet the liabilities?

There might be many ethically acceptable ways to allocate the waste management effort between current and deferred actions. In all likelihood, the criterion of efficiency would dictate not attempting to do everything today to minimize future liabilities-- and in fact it might not be possible to do everything in the present. Some way of setting aside dedicated financial resources to meet liabilities-- like a trust fund-- seems ethically unobjectionable as long as the strategy is otherwise ethical.

At the same time, it would probably not be ethical just to defer acting on the problem. Both direct action and investments in research to ameliorate safety hazards, to minimize toxic waste production, to cure cancer, to identify substitutes for key resources, etc. all help to compensate future generations for the burdens we will impose on them. [Note, however, that it should not be assumed that all goods are substitutable, that every risk or burden can be compensated in this way. It is too easy (and a seductive rationalization) for us to assume that a trade-off that sounds good to us in the abstract will in fact be seen as adequate by those experiencing the concrete consequences in the future. Even if we were certain we would find a cure for cancer, this would not entitle us to impose carcinogens freely on future generations.]

There is a need to balance the risks to which we expose the current generation (or the immediate next generations), risks that can be more readily identified and to a certain extent quantified, against the risks to which we may be exposing some very far distant future people, risks that are much more difficult to quantify. What guidelines and principles should we follow to balance these risks? Does the proposition that we should not expose future generations to a risk that is not acceptable today appropriately address this issue?

Three of the principles listed under d.2) above address directly this question of balancing risks:

3) Near-term concrete hazards have priority over long-term hypothetical hazards.

4) However, this preference for the present and the near future is reduced where questions of irreversible harm are concerned.

5) When an action poses a plausible threat of catastrophic effects, then that action should not be pursued absent some significant countervailing need.

These principles taken as a set provide some guidance although, as indicated earlier, they need to be developed further to provide effective guidance to decision makers. Principle 3 indicates that explicit current risks, like the risk to clean-up workers, should be given greater weight than hypothetical risks many generations in the future, such as the possible exposure of people to a hazard through some plausible scenario. Principles 4 and 5 identify exceptions to this rule based on projected irreversible harm and catastrophic effects. They can be seen as aspects of what is known in the literature as the "Precautionary Principle." As articulated by Richard Howarth, the principle holds that "Inhabitants of today’s world are morally obligated to take steps to reduce catastrophic risks to members of future generations if doing so would not noticeably diminish their own quality of life."13 (Catastrophic risk or damage would be defined using such notion as increased risk, irreversibility, and the scale of human activity and planetary impact of a project. If an important irreversible decision can be deferred

at low cost, it should be, thus preserving options for later generations.) Howarth claims that the precautionary principle can be made operational by reducing it to a two-part test: "Does a particular environmental insult impose catastrophic risks on members of future generations? Can we take steps to reduce those risks without substantively compromising our own well-being." Although he acknowledges that the principle depends on an explicit value judgment, Howarth argues that the principle yields a policy criterion that is operationally decisive under a wide array of circumstances.

With respect to the second question, the proposition that we should not expose future generations to a risk that is not acceptable today is not inappropriate as a baseline, but it can be criticized as inadequate or unhelpful in balancing risks. (See the response to #5 in the Appendix.) Uncertainty about the far future confounds the practical application of the guideline.

g. **Should measures of risk acceptability be considered in the context of individual rights or local rights, or the collective rights of the population?**

The central question here is the appropriate scale for measuring acceptable risk. While this is a crucial concern, it would be a mistake to answer it in the abstract. It is like asking what level of magnification in a telescope or microscope is best: Each level will reveal different things of interest, and none is intrinsically more important than the others. Moreover, adequate analysis will consider all of these and other perspectives separately and together.

Having said that, however, one ethical danger in particular should be noted. Utilitarian arguments based on "the collective good" are often used to impose "solutions" (i.e., burdens) on the local level. What is needed to protect against this is some principle of distributive justice (see h. below).

[I believe that it is more useful in general to speak about justice than about the "rights" of different groups as is done in this question. "Justice" calls attention to the issue of fair distribution of risks, whereas "rights" focuses on the claims of one group against another. Moreover, when the intergenerational aspect is highlighted, the concept of the "rights of unborn generations" is problematic. See the response to #2 in the Appendix.]

h. **In relation to the previous questions, there is the additional issue of the distribution of environmental risks across population groups, called "environmental justice". All communities and individuals, regardless of economic status or race are entitled to a safe and healthful environment. What measures are necessary in the siting of repositories to assure that disadvantaged populations do not bear disproportionate burdens?**

If we collectively lived up to (or even actively embraced) the principle enunciated here that all communities are entitled to a safe and healthful environment, this whole issue and many like it would be transformed. But in fact, we balance this objective of a safe and healthful environment against many other objectives. And in a sense, the whole question-- including the intergenerational aspect-- is one of environmental justice: Who should bear what burdens, in relation to what benefits?

The question of a **disproportionate** burden is especially important. Proportionality is one key element of justice. But this can be a tricky argument to make. For example, it has been suggested by Lawrence Summers,\(^{14}\) chief economist at the World Bank that "... underpopulated countries in Africa are vastly under-polluted..." compared to large urban centres. The idea here is that toxic wastes should be located in low-wage countries since the costs of pollution would be lowest there. It might

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\(^{14}\) World Bank internal memorandum published by The Economist, February 8, 1992. Summers later maintained that his intent in this memorandum was to "sharpen debate" and not to make policy recommendations.
well be, as Summers argues, that "... the economic logic behind dumping a load of toxic waste in the lowest-wage country is impeccable...." But this would only dramatize (if drama were needed) the extent to which economics has been severed from ethics.

Under a utilitarian principle, sometimes phrased as the "greatest good for the greatest number," imposing greater burdens on small populations might be seen as justified, following the (eminently reasonable) assumption that repository sites should (all else being equal) be located in sparsely populated areas. And sometimes the fact that an area already has toxic wastes is used as a rationale for putting additional wastes there. Such arguments can be effectively countered theoretically by appeals to justice and fairness, but perhaps mobilizing political power would be a more practical response.

1. **In this respect, is there an ethical basis for a "host" community to receive some form of compensation in recognition of the service that it is providing to society?**

Market economists would perhaps not see this as a problem: At some price, some communities will be willing to bear the burden of "hosting" a repository. As long as someone-- whether a private concern or the broader society-- is willing to pay that price, a mutually agreeable bargain can be struck (leaving aside questions of potential risks and burdens imposed on neighbouring communities, and whether they can be compensated). At the same time, the "compensation in recognition of the service" will look to many observers like a bribe.

This is to some extent the current situation in the U.S., where a consortium of energy companies is negotiating with the Mescalero Apache Indians of New Mexico (among others) to locate a temporary high-level waste repository on the reservation. To the tribal elders who are pursuing the project, it represents a hope for long-term tribal independence and prosperity. To many environmentalists, it smacks of environmental racism.

The free market ideology would support the idea that communities anywhere should be permitted to enter into a contract to create a repository. Proponents would argue that "anti-dumping" provision that prohibit export of wastes to countries with lower safety standards are too restrictive, and they would champion the tangible value of free choice over some abstract concept of distributive justice. While there is merit in this position, on balance justice seems to require some protection against exploitation (which is not provided by traditional utilitarian arguments).
Appendix
Ethics Questions—Radioactive Waste Management Workshop

This Appendix provides brief responses to the ethical issues raised (beyond the "cost/benefit considerations") in the Background Document for the Workshop. (The questions are paraphrased.)

1. **Can risk, or responsibility for essential action, be imposed (on future generations) when the benefits are perceived to be incurred by others (current generations) and, if so, under what conditions?**

   There are inevitably situations when risks and benefits are not equally shared—when, for example, one generation enjoys benefits and imposes risks or responsibilities on subsequent generations. This can be viewed as a core question of justice or equity. Various criteria can be employed to determine when this is justified and, in some instances, what compensation is due.

   The current generation will pass on both burdens and benefits in some mix—a heritage—and it is not always necessary to consider particular risks in isolation. At the same time, when there is a plausible prospect of a "significant or unacceptable detriment" to future generations, actions should not be taken without systematic review (e.g., life cycle assessment of energy options), and the impacts on future generations should be taken as seriously as if they were to be borne by our own children.

2. **Do current generations have the right to take decisions today which would foreclose options of future generations?**

   It is an unavoidable fact of life that actions today foreclose some options for the future, even as they open others. But we should adopt as a key strategy, and even as a prudent and just principle, to preserve options for the future in major decisions where there is reason to believe those options may have serious impacts for better or worse on their quality of life. [As indicated in section d., this tends to support temporary/retrievable versus permanent storage of nuclear wastes. And, as indicated in section g., I believe that "rights" language is less useful here than a justice framework.]

3. **Could or should the responsibility for developing solutions to the radioactive waste problem be transmitted to future generations? Given the uncertainty of the stability of society, would future generations have the knowledge and resources necessary for the construction of appropriate repositories? Could the degree of endowment of resources specifically devoted to this problem affect that choice?**

   What responsibility can reasonably be put on future generations? It would clearly not be ethical or just to transfer the whole responsibility for developing solutions to future generations—especially when they won’t enjoy the benefits. Even if we had very strong reasons to believe they will have the technical capability to do it more effectively and efficiently (which is open to question), we should accept the principal responsibility for cleaning up our own mess.

   At the same time, it might be reasonable to expect a contribution to the solution from future generations. For example, it might be ethical to defer permanent disposal for 100 years—*as long as* we are doing what we reasonably can in the present to remedy the situation, to keep from adding to the problem, and assuming that we have a reasonable plan.

   With respect to such issues as the stability and knowledge of future societies, our uncertainty is so great that no one’s guess is solid enough to bear weight.
4. Can the concepts of sustainable development and intergenerational equity be applied in a practical way to address the optimum combination of responsibilities, options and resources to be bequeathed to future generations to care for their health and environment.

Practical applications of sustainability and intergenerational equity principles are now being developed, as described in section d.2). But the phrasing of this question seems to imply unrealistic expectations: it would be a mistake to expect that any applications will be universally accepted without controversy, or that "optimizing" in any strong sense of that word (like "one best answer") will ever be possible. This is not a technical problem to be solved, but a situation to be managed over time.

5. In the radioactive waste disposal field, the intergenerational equity principle has been translated into the apparently simple and straightforward requirement that the safety level in the future be equivalent to that which is currently acceptable, irrespective of time, and without the necessity for active intervention by future generations.

a. Does this approach represent an innovation, at least as far as a long-term safety provision is concerned, and if so why?

The current safety guideline should be seen as an interpretation of the intergenerational equity principle, not as a substitute for it. It is not so much an innovation as a reasonable baseline or starting place; under many possible scenarios, the requirement might be too loose or too stringent. Nor is the requirement as "straightforward" as it seems: What is "currently acceptable, irrespective of time" is notoriously malleable and dependent on class, culture, knowledge, values, and many other things.

Moreover, I do not believe that the other part of the requirement, "without the necessity of active intervention by future generations," is straightforward, innovative or well-founded. If it is desirable to preserve options for future generations, their "active intervention" might be required.

b. Is it fair to postulate that contemporary safety norms should be the basis for the protection of future generations. Or is there another way to determine the degree of risk acceptable to future generations?

Using contemporary safety norms as the basis for the protection of future generations should be seen only as a default position. It is not defensible as a "postulate" of fairness. If there were a way to determine "acceptable risk" as it will be seen by future generations, that would clearly be preferable. And it is easy to imagine that future generations might have risk standards very much more strict or considerably looser than our own.

6. Does the application of the sustainable development and Intergenerational equity concepts require that both benefits and costs passed on to future generations be taken into account in deciding what is equitable and what is not?

It is appropriate that both risks and benefits be "taken into account" in deciding what is equitable. Note, however, as mentioned under section e., that using benefits to offset risks may not always be ethically permissible.
Dr. Flowers

We have come to end of the presentations and we can now have a period of discussion on Session II, Ethics and the Environment. I do not think that I will attempt to compartmentalize the discussion into separate papers because any one of these papers could lead into points made by one or the other authors. We have had, of course, three papers on ethics and environment in general terms, Papers 5, 6 and 7; Paper 8 is on the same subject but from the perspective of a nuclear industry chairman. We then had the two papers on the handling of resources between generations in particular.

One of the points that I suggest we do not fail to cover in the discussion is whether those who have thought about what is ethical and what is not agree that the kind of strategy put forward by Colin Allan - the timing of disposal of long-lived waste - shapes up well against the principles which they have enunciated. I am sure there are many other points and the floor is now open for discussion.

Mr. Bernero

I would like to raise a question addressed more to the last two speakers about the discount rate which is a troublesome problem. The discount rate is a question when one is dealing with a present cost and a future later generation benefit. Can we waive or avoid the question if we say we would seek a robust standard and that future impacts would be negligible? It is not a matter of counting cancers in the future and saying whether they cost too much today, but using some principle of negligibility that the risks, or impacts, are so low as to be negligible.

Mr. Berkhout

I think that if a risk in the future is negligible, and it would be negligible in the present day if we were to evaluate it in the present day, then there is no need for discounting at all. Discounting then is a technique which becomes redundant. It does not improve your decision or your ability to judge whether one strategy is better than another. If you have a basic standard of safety for all projects, that is if it somehow falls below something which is measurable or needs to be taken account of in a formal decision-making process, I do not think one needs to discount.

The real problem with cost/benefit analysis is that it is a very attractive and a rather easily useable instrument. Yet, as Professor Catron and I have tried to explain, it is an instrument which has a very specific function which is to make efficient the allocation of economic/financial resources in the short term. It is not an instrument which is useful for questions where the central problem is about intergenerational equity. It is not an instrument which is applicable and, therefore, I am not sure a debate about whether discounting is appropriate or not.

Professor Catron

I agree with what Frans Berkhout just said. Discounting is specifically designed to give a present value for future benefits or risks. If those future benefits or risks are negligible, then there is no possibility that discounting can be useful. However, I think that there is a broader question of balancing the present against the future. While for certain purposes if we can really rely on the actions of the present as being benign for the long term future, then we can safely ignore them. It seems to me, however, quite useful, and I think it is inevitable that we will continue not only in this venue but with respect to other issues, to be increasingly concerned about the relationship between current generations and the heritage that we are passing on, both benefits and risks. This is a useful thing to
do even though there is little chance that we will come up with a definitive methodology for making these decisions.

Dr. Allan

I wanted to make a comment and express a thought centred around the words "irretrievable disposal". It is my view that in the systems that are being considered in most, if not all, OECD countries, final disposal, although not intended to retrieve the waste, does not deny the possibility of retrieval. In that sense, deep geological disposal does not differ in a fundamental way from surface disposal or surface storage in that it would be possible to actually retrieve the material and do something about it. The fundamental difference is in the concept of having a passively safe system that does not rely on institutional controls. Surface-based systems without institutional controls will ultimately lead to significant risk to future generations, not least of which is the risk of future intrusion. In fact, one of the driving forces behind deep geological disposal is to minimize that risk by making the storage not readily accessible.

We have discussed in the NEA issues of human intrusion. We have agreed among ourselves that we are seeking to minimize inadvertent, and not deliberate, human intrusion where intrusion into deep geological disposal is undertaken by a knowledgeable society which recognizes the risks involved and believes that the benefits of intrusion outweigh the risks.

I see a lot of commonality in the approach that is being taken with the concept of a rolling present, introduced by Professor Catron, but with a vision of being able to give to the next generation, or perhaps a generation beyond that, the technological capability of instituting a passively safe system which does not foreclose options. It will then be up to that generation to determine whether or not it shall make the decision to institute that system. What we are doing is developing the technical capabilities which will take a long time to develop, and it will probably be a requirement to take the first steps of actually emplacing wastes before you get to the end point. In two or three generations from now, the real issue will be whether to close the facility, and having closed it does not mean you cannot retrieve the waste. It just means that retrieval will be more expensive. I do not see a great deal of distinction between current storage and disposal except that what we are trying to do is to establish a passively safe system so that if institutional control is lost we have left in place a system whereby we have done our best not to leave a detriment to the future, but rather to minimize the risks to the future.

Dr. Ahearne

I wanted to ask Mrs. Gundelach a question. In your paper, if I understand it correctly, you say that one should look at the sum of the evils and choose the one that minimizes the sum of the evils. I was surprised because I would have thought what you would do is look at the sum of the good minus the evil and try to maximize a positive approach. You left out the good.

Mrs. Gundelach

No, I meant that you have to look for the good and you have to look for the evils and then weigh what is better for your decision. Often we do not take into account the evils, we see only the good and I want to say that we have to look for both. Only then can we make a decision.

Dr. Ahearne

I would agree with that. I just wanted to make sure that there was a recognition of the "good" because I believe that many of the discussions have neglected this aspect.
Dr. McComble

I would like to comment on the issue of passing on burdens to future generations and specifically on how far we have to go towards implementing disposal in order to minimize the burdens we pass on to future generations. Colin Allan's overview paper made a fine distinction about how we have to implement storage as quickly as possible, but that we should also develop the technology for disposal. His paper also mentioned funding. Presumably at that stage you could then decide not to implement the disposal.

As far as I can see there are some good reasons for current generations not implementing disposal. One is that technically it is going to take longer; this, some people argue, is because site characterisation takes decades to accomplish. Second, economically it is not the best option in the short term. There is another argument that comes up very often: it is the wait-and-see, "things will be better" attitude which hopeful technologists and opponents often bring up (I am excluding at the moment, other arguments that opponents bring up). The final argument, which I suspect I hear in some places, is to wait; it takes the heat off the political and social problems. That conflict is a little bit like Frans Barkhout's opinion that one of the biggest burdens we pass on is the social-institutional problem. My question is, are we passing on more burdens if we do the whole of implementation, than if we organise the whole of the funding for the repository and then sit back? Is the latter option less ethical because we have kept one of the political and social burdens there? Or, as Professor Catron says, is that more ethical because we have left the choices open? What is the most ethical time to wait before you implement?

Professor Catron

One of the difficulties of ethical discourse is that it is very difficult to find a single principle and simply maximize it. Often principles are opposed to one another so that there is a balancing act to come to grips with: which principle in a given case should hold sway? This is particularly important when we talk about things like John Ahearne's question to Mrs. Gundelach or Bob Bernero's question about negligible costs in the future. You have to ask "negligible to whom?". If there are deaths involved they would not be negligible to those people who died even though through a comparative risk assessment it might be very small compared to another risk that you may also be obliged to abate.

It seems to me that it is important to use simultaneously the utilitarian argument in which you try to sum the costs and benefits and come up with the activity that has the greatest net benefit. It is also important to look at the question of distributive justice. Who is bearing the burden and how serious is that burden? One of the difficulties of utilitarian ethics historically is that it does not have an adequate principle of distributive justice.

That is not a very satisfactory answer to your question but I would say that you need to balance those two approaches against one another.

Dr. McComble

I want on one point to express heartfelt agreement with you. It seems to me that all of these ethical principles we are putting up are not just contradictory, but also that one can always take one of these principles to justify your point of view.

Professor Catron

I think that would be a mistake. An ethical discourse intrinsically involves the balancing and the thoughtfulness about varieties of points of view, not trying to trump somebody else's argument by citing an ethical principle.
Mr. Berkhout

These are not impossible questions to resolve. We are constantly reminded that societies can make very difficult decisions. As you know, in the United Kingdom, the IRA decided two days ago to call a ceasefire. It seems the end of the war in Northern Ireland is upon us although that seemed difficult for a very long time. Solving the question of disposal of nuclear waste must be a much simpler problem to resolve. Therefore, I would say that since this is not an impossible political decision to come upon, there must be ways - structures of dialogue, forms of education, forms of public participation, forms of prudent state action - which will provide the conditions for a definitive, socially agreed upon decision on either disposal or long-term storage.

This is the most important thing to pursue. All other questions such as financing and criterion fall into place and are driven out of the political discussion we are currently involved in. It is not an impossible decision to make and we must not be pessimistic about it.

Dr. Flowers

I am not sure whether Dr. McCombie feels satisfied. That was a very sensible statement which I think we understand, but there was the clear question of whether in our view - as technical experts and involved people who have thought about the ethics - it is better to do a lot of the work on disposal now, put the system in place, not irretrievably but to put it in place within the sort of time scale that Colin Allan spoke of, or, on the other hand, simply develop the technology, but not implement it at all, develop the science, and pass on a lot of options for implementation.

The costs, presumably, after what you said about discounting, would favour the former; to get on with the job. Is there an ethical argument which could be raised indicating that the other is the better course of action?

Dr. Ahearn

As Charles McCombie knows, I am not an ethicist. There is, however, an ethical argument that says the alternate approach is the better one. A fundamental problem that we have found in the United States, and which is not dissimilar to the low-level waste siting problem Bob Bernero referred to, is the ethical consideration of a correct course of action. In a democracy this must involve the affected populace. The most affected populace are those who are saying they do not like the approach being taken. The ethical issue which is being faced is: is there something uniquely dangerous or important about solving the high-level waste problem when it requires overriding the rights of that populace? I suspect that most technologists are willing to say yes, they can be overridden because we technologists tend to conclude that the public is acting in an irrational manner; that it is not that big of a hazard so they should not be that concerned.

Dr. McCombie

I agree that it is not ethical to override people, but I think it goes somewhat further than that. If you agree it is not ethical to override the people who are being overridden in some given situation, then I think it is also not ethical to shelve the problem because of that. You have to look for another group of people you do not have to override. You have to push ahead with the problem. It seems to me that one of the main arguments I have heard concerning the social burden is the cost of doing the thing; it is better to put the problem aside and hope the situation will get better; to wait for political peace. That is not ethical: to put the problem on the shelf.
I am not saying that you push it through wherever you happen to be. I am saying that if you think you have made a mistake in taking the wrong approach, then if you back off it is not ethical to sit still and hope things will get better for some undefined reason.

Mrs. Greber

I think this is the real difficulty with the whole cost/benefit analysis argument to discounting. To me discounting is a tendency to avoid taking responsibility for posterity. The further into the future we look the less likely we see that we have any kind of responsibility. I think we recognise there is a very good possibility that in the future people will be different than they are today, or that there may be a possibility there will not be people in the future. We should act as though there will be people in the future and that they will be very much like we are today. By assuming there is a probability that we have obligations, we can ensure that our obligations are met.

Dr. Allan mentioned this morning the kinds of things we see as being requirements - choices and flexibility, the ability to be able to participate in the decision-making process, fairness, and openness. If we assume that we have a responsibility to meet these requirements today, and if we assume that we have responsibilities for future generations because they are going to be similar to us and have similar requirements, then we would want to ensure that we follow through with those kinds of commitments; that there will be flexibility, participation in decision-making, openness and due process.

Mr. Bernero

I would like to make a few remarks somewhat along the same lines as the question raised by Dr. McCombie. To illustrate what I think is a primary concern, I would like to have the temerity to use the French facility at Soulaine. To put it simply, there exists in Soulaine a low-level waste disposal facility which has multiple barriers, exceptional mechanisms to prevent migration of the radioactivity into the environment and analysis to show that whatever radioactivity might come out would be negligible. Nevertheless, the waste is engineered in such a way as to be essentially retrievable and has full-time long-term monitoring. It is as if to say: any future generation can know if this facility is turning out to be a time bomb.

Our ethical question today on high-level waste is: what should any national programme do today? Should it foresee that we would sooner or later like to build a Soulaine for high-level waste, but just think about it now? Or, should we think that through very carefully, recognising our obligations to future generations and get under way to implement that solution? That is the real ethical question today. It is not whether waste is put into the ground tomorrow or next year or ten, twenty years from now. The real question is: are we implementing, are we satisfying this generation's obligation to do something or are we merely thinking about it and setting aside some money? Ploughing funds into the economy in such a way is to say that we have now shed our responsibility and passed it onto society at large and to later generations.

Mr. Lefèvre

Je vais être beaucoup plus court que je ne le pensais parce que le M. Bernero vient de dire sensiblement ce que je souhaitais dire moi-même. Sur ce point qui a été souligné par M. McCombie et dont on discute depuis un certain temps, je crois qu'il est effectivement, du point de vue de l'éthique, absolument nécessaire de faire quelque chose. Il ne faut pas attendre. Excusez-moi Dr. Ahearne, je ne suis pas de votre avis; il n'est pas bon de prendre la décision d'attendre. Il faut aller de l'avant, quitte à se tromper, avec cette possibilité, cette parade, qu'est la réversibilité.
Etudier les possibilités de reprise des déchets dans le futur, même si on n'a pas besoin de le faire, est absolument une nécessité. C'est la position intermédiaire entre celle qui serait d'attendre et celle de faire le définitif tout de suite. Cela me paraît assez évident qu'aujourd'hui on ne peut pas convaincre le public de faire du totalement définitif, de l'irréversible comme on l'a dit. Il faut aller de l'avant - décider, faire, réaliser - mais simultanément bien dire au public que s'il y a un problème on pourra reprendre les déchets. Le droit à l'erreur doit être affiché.

Je pense à quelque chose qui va peut être un peu loin, mais qui paraît illustrer ce droit à l'erreur. Un ministre de Louis XIV avait décidé pour le bien des générations futures, au sens de l'éthique, de planter une forêt de chênes, qui est la forêt de Tronçais en France, pour qu'on puisse construire au vingtième siècle des navires et avoir une flotte de bateaux avec des bois de chênes tout à fait convenables. Cette forêt existe, elle est belle, on n'en profite pas pour l'usage qui avait été prévu par le ministre de Louis XIV, mais enfin elle a le mérite d'exister et donc on peut en profiter au point de vue de l'écologie.

(I will be much briefer than I expected because Mr. Bernero has just more or less said what I wanted to say myself. On the point raised by Dr. McCombie, and which we have been discussing for a while, from an ethical point of view I think it absolutely necessary to do something. We must not wait. You must excuse me Dr. Ahearne, I do not share your opinion: it is not good to take the decision to wait. One must go forward, even if one makes mistakes, with this possibility, this parade, which is reversibility.

It is an absolute necessity to study the possibility of retrieving wastes in the future, even if this is not required of us. It is an intermediate position between those who would like to wait and those who want to take a definite decision right away. It seems clear today that one cannot convince the public to accept a definitive, or irreversible, course of action. One must go forward - to decide, to construct, to finalise - but one must, at the same time, be able to say to the public that should a problem arise, we can retrieve the wastes. The right to err must be clearly stated.

I am thinking of an example which might be a bit extreme, but which illustrates this right to err. A Minister of Louis XIV decided for the benefit, in the ethical sense, of future generations to plant a forest of oak trees for the construction of ships in the 20th century. This forest, which is Tronçais Forest in France, was to provide appropriate oakwood for future fleets. This forest exists, it is beautiful, and although one does not take advantage of it for its original purpose as planned by Louis XIV's minister, it has the merit of existing and one can profit from it from an ecological standpoint.)

Mr. Thégerström

I have an observation on the process of implementation which in itself may cause burdens. In contrast to far future risks, we can monitor this burden of decision-making while we are going forward. Real time monitoring allows us to see how difficult the process will be, and we can get feedback and adapt the programme in accordance to the information obtained. If it gets too difficult to take the difficult decision to go forward, the process can be slowed down and other alternatives looked for.

This process could be compared to a car. You need an engine, some steering and brakes. The engine, of course, has to be provided primarily by the industry, at least in our country industry has this responsibility. The steering must be provided by the regulatory authorities, and the brakes by the opponents or whatever. All three functions are essential in order to drive the car safely. The ethical thing is to carefully go forward and the unethical thing would be to stop the car, take out the key and
say that somebody else in the coming generations will have to deal with the problem. I feel that only studying options and alternatives and putting the books on the shelf is like stopping the car.

Mr. Allègre

Je crois que, effectivement, l'exemple de Souilane est une bonne comparaison car si nous avons mis à Souilane des déchets très faiblement radioactifs sous surveillance pendant 300 ans, c'est parce que nous estimons, premièrement, que dans 300 ans la radioactivité sera quasi nulle, et que, deuxièmement, nous pensons que les institutions humaines - notamment les institutions politiques - auront suffisamment de continuité pendant trois cents ans pour assurer la surveillance dans de bonnes conditions.

Lorsqu'on parle de déchets à vie très longue, dont la durée de vie se chiffre en milliers, voire en centaines de milliers d'années, on ne peut faire aucun pronostic de ce genre. Donc c'est précisément parce qu'on ne peut pas supposer que le contrôle institutionnel sera valable et efficace pendant des centaines de milliers d'années qu'il faut trouver une solution qui, elle, fonctionne pendant des centaines de milliers d'années. La solution de laisser les déchets à vie longue en surface ne pose pas de difficulté pour quelques dizaines, voire une centaine, d'années, mais elle devient impensable dans la très longue durée. Aujourd'hui la seule solution que nous avons tous trouvée, c'est de mettre les déchets à vie longue dans un stockage géologique profond.

Alors, quelle est la responsabilité de notre génération aujourd'hui, génération au sens large? Ce n'est certainement pas de ne rien faire et de penser que les générations suivantes résoudront le problème. Je crois qu'il s'agit d'un alibi, qui revient à se montrer réellement irresponsable à l'égard des générations futures. Si par contre nous disons: on peut laisser les déchets en surface, ils y sont déjà, mais pendant un temps qui est fini et non pas infini, c'est une situation responsable, pourvu que pendant le même temps nous passions le maximum d'efforts pour mettre en place la solution du stockage géologique. Nous savons tous que la solution du stockage géologique a de très grandes chances de marcher mais qu'il nous faudra des dizaines d'années pour la mettre en place; il nous faudra des dizaines d'années pour convaincre les scientifiques d'abord, les opinions publiques et les politiques ensuite. D'où la nécessité d'un processus pas à pas dans lequel nous sommes tous engagés.

Ce que je dis simplement, c'est engageons ce processus. Allons-y avec le maximum de force. Et nous prendrons là une attitude responsable vis-à-vis les générations futures. Au fur et à mesure, à chaque pas, du processus il appartiendra aux responsables du moment de prendre les décisions. Mais au moins mettons nous aujourd'hui dans une situation telle que nous permettrons demain, dans un futur immédiat, à ces responsables de prendre les décisions. Si nous ne faisons rien et si nous nous contentons de poser la question et de nous dire "laissons la au suivant", nous sommes alors vraiment irresponsables et nous agissons vraiment contrairement à l'éthique.

(I think, actually, the example of Souilane is a good comparison because if we have placed radioactive wastes under surveillance here for the next 300 years, it is because we consider, first, that in 300 years the radioactivity will be practically non-existent and, secondly, we think that social institutions - particularly political institutions - will have sufficient continuity over the next 300 years to ensure proper surveillance conditions.

When we speak of long-lived wastes, which persist for thousands or even hundreds of thousands of years we can make no such predictions. It is precisely because we cannot guarantee that institutional controls will remain effective over hundreds of thousands of years, that a solution which will work over hundreds of thousands of years must be found. The solution of leaving long-lived wastes on the surface is possible for a period of several decades,
or even a hundred years, but is unthinkable over the long term. Today, the only solution we have found is to place long-lived wastes in a deep geological repository.

What then are the responsibilities of our generation, generation in the larger sense? It is certainly not to do nothing and think that the following generations will resolve the problem. I think this serves as an alibi which only demonstrates a real sense of irresponsibility towards future generations. If, on the other hand, we say: "we can leave the wastes on the surface, they are already there, but only for a definite, and not indefinite, period of time", this is acting in a responsible manner provided that concurrently we make a maximum effort to start the process of deep geological disposal. We all know that deep geological disposal has every chance of succeeding, but that this will necessitate decades to finalise. It will take decades to convince scientists in the first place, and then, afterwards, to convince public opinion and politicians. This will necessarily entail a step-by-step approach to which we are all participants.

I am simply saying that we must start this process and we must do so with a maximum of effort. This would be a responsible attitude vis-a-vis future generations. As we advance, at each step of the process, it will be necessary for those in charge to make decisions. Let us at least position ourselves today in a situation that will allow the decision-makers of tomorrow, in the immediate future, to make those decisions. If we do nothing but ask questions and answer "leave it to the following generation," we are then acting in a very irresponsible manner and contrary to ethical behaviour.)

Mr. Berkhout

I wanted to continue this discussion by making two points from the sociology of knowledge, from the sociology of science. The first point is that knowledge is cumulative. That is, science moves forward under conditions of bounded rationality. To give a comparison from evolutionary biology, the evolution of horses began with eohippus, a very small-like horse creature, and developed into modern, larger horses. Science is also bounded and moves along a particular trajectory. If that is true then future waste disposal concepts are likely to be similar to the basic concept we have today. There are basic physical and economic problems associated with more or less all the other options. The second point is, if this is true what we are doing today with repository science, with the development of assessment techniques, safety assessments, computer modelling, and so on, is not necessarily just the improvement of the technology of repositories, it is really a science aimed at legitimising the concept we have. Therefore, it is a science with a particular social purpose. It is not a science which is moving ahead under its own steam as it were. It is a science which has a specific function which is to assure publics that the concept we have is safe. What is at issue is not the concept of disposal, but whether we can provide the conditions of knowledge that will allow us all to agree that this is the safe and correct way of going about it.

These two points confirm an argument for going ahead with developing disposal concepts because what we will end up with, even if we wait, will be similar to what we have today. The model of the car, which will still be a Volvo in the Swedish case might be a slightly different Volvo because the engineers will have tinkered with it and so on, but it will basically be a Volvo. What we are considering is developing science to assure ourselves that the Volvo is safe enough.

Mr. Schaller

I would like to say, first of all, that I agree completely with the arguments brought forward by M. Allègre. I would, however, like to come back to the last two authors on the cost/benefit calculations and the purely financial aspects of the matter. You rightly said that discounting procedures probably cannot be applied to the far future and this is certainly true. However, for heat generating long-lived
waste, there is an obligation to pass on the load for about one generation because you have to wait twenty or thirty years for the decay of spent fuel before going underground. There must be some financial instrument to take care of this load, which has to be done in any case, in one generation from now for spent fuel unloaded at the present time. If we look back thirty years ago, we see that discounting would have worked perfectly.

This would be an argument to say: we delay the disposal as long as possible because it has worked in the past. However, in reality, if you look back thirty years the costs, even if you discount the real costs, are higher now. Mr. Bernero has given some reasons for this for low level waste; that there have been additional regulatory problems, lower limits, etc. Non-financial reasons have made it more expensive to carry out disposal. In studies on decommissioning made by the European Commission we have looked at delaying decommissioning. These studies were conducted twenty years ago as well as recently and we have seen the same effect. From the purely financial point of view, if you take into account the evolution in politics it is probably better to implement deep disposal as fast as possible. We are now at a point in time where we could go for disposal of the first generation of spent fuel. I think it would be timely to go ahead and realize deep disposal.

Mr. Berkhout

I think over the period of a generation of thirty years, the operating life of a reactor, it may very well be completely legitimate to discount financial streams of cost. I am not arguing with that. Obviously future escalations in price can be coped with by building in contingencies. One needs to be conservative about what the future will demand. I think also that when it comes to disposal, one needs to take the pessimistic assumption that there will be early disposal.

If one started operating a reactor today and it was going to operate for the next thirty years, one would need to assume that all the funds required to dispose of all the fuels in a currently conceived repository, could be disposed of on the day the reactor stopped operating. That might be a criterion one could apply to these funds which have to be built up.

Professor Catron

I wonder about the last claim. It seems to me that the appropriate way to approach this might very well be not to assume at the outset what efficiency, or effectiveness, or equity would require, but to develop a strategy that might in fact take certain kinds of actions now and defer other kinds of actions later; a strategy that would work out a sequence along the lines described to us this morning. This may or may not be true, but it is not obvious at the outset that efficiency requires doing everything now. At least, it is not obvious to me.

Mr. Saltzman

This has to do with those to whom the ethical question most relates. John Ahearn has suggested that it is to the most affected populations, namely those in the locality where the repository would be located. I would suggest that you would not want to lose sight of those affected populations whose consciousness may just now be being raised. That is, those in the vicinity of the reactors who have expected that the waste will be removed. If you go into a process of long term storage rather than disposal, you may well find that for these populations the waste will be around for a long time. They could also be the "most affected" populaces.

Dr. Flowers

Yes, I suppose that is one of the evils that Mrs. Gundelach would put into the equation.
Dr. Allan

I wanted to make a few comments concerning the continuity of the knowledge base. In Canada, and I believe in a number of other programmes around the world, we have reached the point where we have developed the basic understanding of the important scientific elements. The next logical step, and the next logical way of building the knowledge base and sustaining it, is to move from a generic based programme to a site specific project programme.

In moving in that direction one will not be making a decision on emplacing waste for another fifteen years at the earliest. So continuing the development of the technology, continuing to maintain the capability of moving from knowledge development as a science activity to a project activity still keeps open the option that in ten to fifteen years from now a future group of people will make the decision to emplace wastes. If the decision is taken to emplace wastes then that will take a further period of time and another group of people will have to make a decision about whether or not to eventually close the facility and put it in a passively safe state.

In taking those decisions in the future and in taking the decision today about continuing programmes and moving towards a project basis, we have to examine the alternatives. Although there is the potential for developing other processes that may ameliorate the waste to some extent there is a broad consensus by the people in this room that the best approach for disposal and for the long term management of nuclear fuel waste is still based on deep geological disposal. It is, therefore, an approach we should continue, while keeping an open eye for alternatives should they develop. We are not foreclosing any options by continuing that process.

If I think of the analogy of the car that Claes Thegerström raised, if you step away from the car and let it sit still for many years, you may not be able to start it again. You cannot maintain your knowledge base without making progress. So there is a requirement to continue if you want to maintain and pass on to the future a knowledge base.

Dr. Röthemeyer

One may not even have the petrol to start the engine again. Therefore, the stability of society is something which must be relied upon if a decision or action is postponed. As we are all aware, we have states where social stability is not there anymore and the ability and means of these states to deal with problems are not there. They have the problems of their own generation, and a few years later they are still not able to solve them. If they had options, they would not have to think about these options. So the stability of society is a point which has not been tackled sufficiently when one postpones a decision or an action to a later time, for decades ahead.

Dr. McComble

I was also thinking of this car analogy and of Frans Berkhout's comment about the car continuing to be a Volvo in the future. I would like to play the devil's advocate and point out that, if you had been talking a hundred and fifty years ago, you would be predicting that all Swedes would still be on horseback today. The analogy does not have to go through like that. There can be changes. Science is not linear. That is the argument we always hear from the repository sceptics: something new and marvellous could appear. So there is an opposite argument and I have taken the role of a devil's advocate by putting it on the table. However, I would also like to oppose my own argument.

If we were doing a journey that you could do on horseback, we should have done it back then when we had the horse. It not necessary to wait for the car anyway. It may not be the best solution, but if we think there is a societally acceptable solution now that is the argument for pressing ahead.
with it and for not waiting for something better. The big public debate is whether it is accepted that we have today the right solution or not.

Dr. Ahearne

I feel that my opinion is clearly a little bit different than many of yours here. However, there is something quite different which has not been taken into account. Most of you do not have a specific site that your country has chosen to put the waste in. Consequently, most of you are still in the factory building the car. The situation we in the United States have is whether we take the car on the road. The issue I have been addressing is when you start selecting that site, what do you do? It is not a question of whether geologic disposal is the best solution we have right now. The question is how do you go ahead with that? All of you are talking about a situation that in most your countries is still many years away. When I ask: when are you going to actually select the site? most answers are "years ahead from now". Why? Because it is very difficult to do that. The question then is: how do you go about doing that?

Many of the comments I have heard remind me of debates I participated in over fifteen years ago on breeder reactors. The issue then was that we had to move ahead immediately and build breeder reactors. It was believed we had that responsibility to future generations because we all knew we were going to run out of uranium and it was absolutely essential to move ahead with a strong breeder reactor programme. Of course, as you know, that is not the way things turned out.

The nuclear industry has, and maybe in your country it is different, shot itself in the foot, to use an American analogy, in the sense that it became its own worst enemy. If you tell the public that if we do something wrong it should not worry about it because in the future we can fix it, the general public, at least in the United States, would not believe the nuclear industry or the Department of Energy. One must make sure, and I emphasize this once again, that the people most affected have the opportunity to participate effectively in the decision-making process. An early American, Thomas Jefferson, pointed out that it was most necessary to get that discretion raised. There is a very big difference, as we have found out in the United States, between doing the technical analysis and the exploration necessary to know if a geological repository can be built and actually finding a site and going ahead with it.

Dr. Allan

I was going to comment on the suggestion concerning the discounting of money and the necessity of having a strategy. In Canada, and I am sure in most of the other OECD countries, the waste producers are making financial provisions which are based on estimates of costs, times of implementation, and when those costs will be incurred taking into account the time value of money. The actual full cost is not going into the bank today, but we are taking account of the interest that those funds will accrue and when the expenditures will likely be made. This provides a financial constraint on the rates of progress, on the rate at which implementation will proceed, unless you suddenly make a change in the provisions you are making.

I would add one comment on John Ahearne's discussion. Certainly in Canada, and I am aware of the situation in Sweden and it is rather similar in Finland, public involvement at the local level where the site is being considered is a very important element of the siting strategy or an implementation strategy. We will shortly be tabling an environmental impact statement to respond to guidelines that have been put forward by the review panel that Dr. Roots talked of earlier. One of the explicit statements we make is that as part of a siting strategy we will not seek to impose a facility on a community that does not want it. That siting strategy has successfully been used in Canada to establish waste management facilities for toxic chemicals. It does not mean that every community will accept such facilities, but the experience has been that some communities will.
Dr. Flowers

John Ahearne has raised the analogue of the fast breeder reactor, which I could say a lot about, but what we are looking for is a reason why the deep geological disposal option, which we favour, is the ethically sound option. We cannot see anything else on the horizon that is likely to challenge it. Is there anything in the comparison with natural analogues? I am reminded that when we had the talk from Mrs. von Rein on mercury, she spoke about putting it back where it came from. That suggests that deep geological placement is the natural and the proven place for toxic mineral ores. This has been proven not over thousand of years, but thousands of millions of years. Is there some reason of this kind why properly implemented deep geological disposal is an option we should feel rather secure about?

Mr. Allègre

Je ne crois pas que les stockages profonds géologiques doivent chercher leur justification dans le fait de rendre à la nature ce qui y était auparavant. Ou alors je dirais comme certains anti nucléaires en France, qu'on peut nous opposer une autre analogie, c'est celle du chat. On dit que le chat quand il a fait une crotte, excusez-moi, qu'il l'enterre et ensuite la cache pour qu'on ne la voit plus et que nous les nucléaires, nous faisons la même chose. Eh bien non: nous utilisons les capacités naturelles de confinement de la géologie.

Si on peut parler des analogues géologiques c'est pour y chercher un exemple de quelque chose qui a été gardé par la nature pendant très longtemps. Les analogues démontrent que, dans certaines circonstances, la géologie peut être étanche et peut conserver des produits pendant des millions d'années. C'est exprès que dans mon papier j'ai cité l'analogue pétrolier, qui n'a absolument rien à voir avec l'uranium naturel ou autre, pour bien montrer que la nature, dans certaines conditions, a des capacités de confinement considérables; c'est exactement ce que nous cherchons. Nous cherchons à confiner des produits d'une très longue durée de vie pendant très longtemps. Nous cherchons à éviter qu'ils ne réapparaissent. La nature nous montre de très nombreux exemples de situations de ce genre. C'est pour cela que nous allons mettre nos déchets dans la nature. Ce n'est pas pour les rendre à la nature; c'est parce que la nature - et là j'emploierai un terme qui est très utilisé par les pétroliers - nous offre un piège. Quand les pétroliers cherchent un gisement, ils cherchent d'abord un piège. Le mot dit bien ce qu'il veut dire: un endroit qui aura piégé les hydrocarbures. Nous cherchons à piéger quelque part dans une formation géologique les déchets radioactifs. Il n'y a pas à chercher d'autres raisons philosophiques à cela.

(I do not think that deep geological repositories must be justified by the principle of returning to nature what was once extracted from it. Or, I would say, as certain members of the anti-nuclear establishment in France have already said, that one can oppose us another analogue, that of the cat. We say that when a cat relieves himself, he buries and hides the droppings so that no one will see it. Our opponents say that we in the nuclear industry do the same thing. In fact, this is not so: we use the geological capabilities of nature for confinement.

If one speaks of geological analogues it is to find an example of something that has been contained by nature over a very long period of time. These analogues demonstrate that under certain circumstances, geology can be leaktight and can preserve products over millions of years. In my paper, I purposefully cited the petroleum analogue, which has absolutely nothing to do with uranium, natural or otherwise, to demonstrate that under certain conditions nature has considerable containment capabilities; this is exactly what we are looking for. We are looking for ways to confine long-lived products over very long periods of time. We want to avoid that they come back to us. Nature has given us many examples of such types of situations. This is why we are going to use nature for our wastes. It is not to return them to
nature; it is because nature - and I will use here a term used in the petroleum industry - offers us a trap. When petroleum specialists look for an oil deposit, they look first for a trap. The word says what it means: a place which has trapped hydrocarbons. We are attempting to trap radioactive wastes in geological formations. There is no need to look for other philosophical reasons.)

Dr. Röthemeyer

Just a short comment on the natural analogues and the sites you were mentioning. We indeed have investigated two sites. One site has been investigated since 1975, for which the whole siting process is almost finished now. A second site has been under investigation since 1979. With respect to natural analogues, we have proved that the isolation capacity which our French colleague spoke of is a feature of the geological structure. We have proved that the isolation capacity for either very small or very large quantities of solution, up to 100 cubic metres, has been present since the formation of these geological structures 250 million years, or 150 million years ago in the other case. Our strategy is to emplace the wastes in a way that this isolation capacity would not be endangered. We are trying to imitate nature and that gives a lot of confidence. I must honestly say that this does not, however, solve all the problems with the people in the area.

Dr. Van Enst

One of the former speakers mentioned already that nature has proven over millions of years that it can contain quite dangerous material close to or below the surface. Salt is one example. There is another argument which makes deep geological disposal favourable. The surface we are living on is the working floor of nature. You can calculate a risk, but if you leave the radioactive waste on the surface for a considerable amount of time, if there is an ice age followed by a large flood, if there is a meteorite, etc., the surface is the first part of nature that will be hit. If you look at the Dutch map of one hundred years ago, it is totally different from the map today. If you go back a thousand years you can recognize The Netherlands, but the differences are very great.

It is perhaps technically possible to have containment on the surface which has very low risks if you put enough money into it and keep it well maintained. However, when something happens, the natural reaction of people is to go away. They will not care for the radioactive waste. At that moment, the people will not care for the future generations; they will just think of themselves. This is a very human reaction, but when we are in a position of knowing that people will react in such a way, we should know better. Therefore, one should think very hard about deep geological disposal. It was mentioned a couple of times that the process must be transparent because people do not believe us any more. That is very cynical because we know ourselves we are so right. Why do people not believe us anymore? We must work very hard at transparency.

Dr. Bloser

In order to construct a repository we have to solve the problem of long-lived radioactive wastes. When we decide to do so and we construct, design, etc., we have to choose technical solutions to specific questions. The question then arises in choosing a technical solution, is this ethically responsible? My question to Professor Catron is to ask if there are any time limits in the principles he mentioned? It makes a difference when I consider the future generations for fifty or hundred years or thousands of years. If I take, for example, retrievability or no retrievability for which period of time do these considerations have to be applied. Is the applicability to be extended far into the future, let us say one hundred thousand years, or is fifty years sufficient?
Professor Catron

Yes, I think there is a time dependency for certain of the principles. The principles listed as 3 and 4 in my paper, the near term concrete hazards, have priority over long-term hypothetical hazards and the fourth principle. However, this preference for the present and the near future is reduced where questions of irreversible harm are concerned. In the literature I am familiar with and in the discussion that lead to the development of these principles, there seemed to be a breakpoint at about a hundred or hundred and fifty years such that the ethical consideration of the nearer term, less than 100 or 150 years, was different from that beyond 150 years. There is obviously no clear-cut formula or boundary. The idea seemed to be we can in fact more legitimately assume that generations to come in the near future are going to be enough like us that we can make some assumptions about their priorities and their values. When you begin to look out further, a thousand years or ten thousand years from now, there is really no legitimate basis to make any claims on what human societies will be like. This is the difficulty when you try to balance. You can balance over a nearer term much more easily than over these very long time frames.

I should add an additional aspect to that. We have to be concerned about natural bias in favour of the near term. We have to be concerned with the time bombs we might be planting that will affect people over very long time periods, for whom we cannot concern ourselves deeply in the present, for whom we cannot form any affinity like we can with our children and grandchildren. The struggle is, in part, to develop the ability to be empathic towards people whose outlines can only be vaguely discerned at this point.

Dr. Dejonghe

I have a comment addressed to Dr. Ahearne who made the remark that most of us are talking of hypothetical sites whereas in the United States they are referring to Yucca Mountain. I would remind him that there are at least a couple of sites in France, for low-level radioactive waste of course. In Belgium, which is a very small country, what we did was very much along the lines explained by Colin Allan this morning with one exception. We have selected a site for further work, but we have not decided on the final site. We selected the site to be able to know what we were talking about, and in this approach we are very much in line with the Canadians. It is a progressive system. We think we have made the best choice and if we have made this choice it is because we thought it was best for the country. From there you continue to build up your knowledge of science, your experience, your technology. We are drilling and we are making galleries. We are making in-situ studies and this is gradually followed, step-by-step, by official approval. We do it now with the national organisation on ONDRAF and, before, as the Mol CEN Nuclear Research Centre.

Dr. Flowers

Thank you and I hope John Ahearne will come back tomorrow if he reflects on his ethical arguments over night. I don't want to rush you on this because it is important that we hear your side. We hear these stories which we have just heard from the nuclear industry all the time in this committee and we very much want to hear the other side.

Mr. Schaller

I would like to come back to Dr. Ahearne's argument that deep disposal has not yet been made. Let us be careful. In reality, this is not true. Deep disposal has been made on a very large scale in the former Soviet Union. In particular, there is a deep disposal site at Tomsk where about 40,000 cubic metres of reprocessing work has been injected to a depth of 700 metres. The "virginity" of the earth concerning deep disposal no longer exists. This site is not so far away from the U.S. by the way. What is astonishing is that in the West, and this may be because we are in an OECD
environment here, nobody looks at this example which is much better than any natural analogue. As it looks now there has not been very much migration and dispersion. We will try to look into that in more detail in the future. I repeat, deep disposal has been done under conditions which are certainly worse than what we would like to do in the West with deep disposal of solid material.

Dr. Ahearne

The point was not that deep disposal has not been done. I am somewhat familiar with the example of the former Soviet Union. I and others have been working with a number of people trying to figure out how to go about handling much of the waste in the former Soviet Union and I would not like to use the approach taken there as the model for other countries to follow.

Mr. Van Miegroet

I would like to offer a suggestion about how to proceed with some of the waste. I would say that we probably have to attempt to collectively extract ourselves from a situation into which we have been pushing ourselves, namely promising the same level of safety to future generations that we are presently offering our own. I am extremely pessimistic that we will ever be able to fulfill such a promise. I have been reading that in a benchmark made here at the NEA some time ago, I think it was about the Yucca Mountain hydrology, there was a difference between the highest and the lowest mark, I recall 25 or 35 orders of magnitude in some doses, that the future population would receive. The NEA has decided until further examination not to publish it. I do not think, however, we will ever be able to generate the type of information and moderation needed nor to demonstrate that it is needed in order to fulfill that promise.

I suggest that we ought to make a dedicated effort, including philosophical statements and discussions, to extract ourselves from that untenable position. We would not be the only one to do that because I am under the impression we are actually the only ones to make such a promise. After all, we are at the moment depleting the petroleum under the North Sea and nobody has ever raised a question as to whether we should not leave that petroleum in place for future generations. In another example, some decades ago practically all European countries decided at the political level that in the future they would substitute the so-called capitalization to pay the retirement allowances with the so-called repartition techniques; our generation, or maybe the former one, has decided to increase its comfort by letting the next one pay its pension allowance. So I think we are more or less isolated in making that type of promise to future generations.

Dr. Flowers

Thank you for that contribution. I think this touches very much on the 1991 technical collective opinion which we already put out on the possibility to make reliable long-term safety assessments.

Mr. Olivier

I think I should make a clarification about what Mr. Van Miegroet has just said concerning the tremendous range of uncertainties about our safety calculations at NEA. If I correctly understood what Mr. Van Miegroet was referring to, it was not a benchmark, but an attempt to push people very far with their ability to use probabilistic methodologies to do some calculations in a loose context and assess model uncertainties using data on the WIPP site, not on Yucca Mountain. We have stopped short this exercise not because there was a big difference in the results but because people proved their inability to some extent to use certain methodologies for certain aspects of risk assessments. This is quite different from the safety assessment in itself. I just want to be clear about this point.
SESSION III

REVIEW OF THE GEOLOGICAL DISPOSAL STRATEGY
FOR LONG-LIVED RADIOACTIVE WASTE
AND ITS IMPLEMENTATION
Preliminary Remark

Dr. Flowers

Ladies and Gentlemen, we now start our second day. Yesterday we heard quite a lot about the radioactive waste management strategy for long-lived wastes and for toxic chemical wastes. We also heard how attitudes to environmental protection are evolving and we heard some views on the implications of looking for ethical strategies. We have noted the effects of sharing concern for future generations, people whom we can never know or consult, and we have heard some views on the passing of resources and liabilities to future generations. In Session III we will review how radioactive waste management plans match up to our picture of responsible ethical behaviour.

In yesterday’s discussion there were still views being offered by, for example, John Ahearne, Mrs Gundelach and Fred Roots, which I think will find ample opportunity for expression in the discussions of Topic C implementation strategies and Topic D, on retrievability. That seems to me when they will be most relevant, but, of course, we will have some discussion after each topic this morning.

Our first topic is the question whether all relevant issues have been identified in yesterday's discussion and Bob Bernero of the US NRC is to be our rapporteur. He will give us a quick resumé of where he thinks we reached on that subject.
Topic A
Have All the Relevant Issues Been Identified?

Robert M. Bernero
US Nuclear Regulatory Commission
United States

We have tried during this workshop to keep our attention on ethical/environmental issues and strategy and to avoid, if possible, bogging down on the decision-making process which is often unique to each nation. However, as you heard yesterday, there are many instances where the decision process is useful in discussions on ethical principles and environmental considerations.

You may recall that in the background paper we had a whole series of issues that were very broad and I tried to extract the following three points as a summary of these issues:

a. Can risk or responsibility for action be imposed on future generations?
b. Are current safety norms suitable for the future?
c. What controls are appropriate for intergenerational cost/benefit evaluations?

The first point is a fundamental consideration. There are many aspects to it. When I start to speak of the issues I have heard, I will tend to pick up many other aspects of the issues we are discussing.

The second: are current safety norms suitable for the future? is not specific to safety considerations but also to the ethical and environmental principles we have today. Will these same principles prevail in future generations? Are they an appropriate legacy to expect?

Point C brings us to the issue of what is a benefit to us today, the generation of power with nuclear technology, may be a cost to future generations left with some residual risk associated with the waste.

Let me break these points down and start with the transfer between generations of risk or responsibility. Our colleagues from the Environment Directorate have made a great contribution to our considerations. I am speaking somewhat parochially as a member of both the Radioactive Waste Management Committee and of the Establishment trying to analyse the ethics of environmental considerations. The Environment Directorate has indicated to us, in Bill Long's paper for example, this trend towards environmental management prevailing throughout technology, as well as the whole idea of reducing cost to society. Cost in all senses, not merely expenditure of resources, but also damage to the environment.

The sequential consideration of the issues involves the minimization of wastes, recycling of waste materials, storage of waste materials and ultimately disposal of waste materials. We heard from our environmental colleagues and people from member nations the theme of considering each of these steps carefully as the underlying basis for decisions on national programmes. However, we also heard some very important variations in how people approach these sequential considerations and what they cover.
One of the most important differences came out in Victor Morgenroth’s oral presentation. You may recall he spoke of the Agenda 21 from the Rio Conference. He said there was a chemical agenda and a nuclear agenda. He gave us a word count which was a dramatic demonstration that in the chemical arena there is a regular almost systematic choice: do I really need this waste material? In the nuclear field there is little, if any, consideration of prevention, of asking the question: do I really need to have the waste?

This brings us to the question that we did not hear a lot about yesterday: in nuclear technology, should prevention be a choice? Is it like the chlorofluoro carbons, the refrigerants, that once the industry was pushed, as Bill Long said, they were finally able to figure out a way to replace them? The Dupont company in the United States, which was the principal manufacturer of CFC, after being pushed finally decided they could economically make the alternative, R134A. Although we did not hear much on this issue yesterday, we in the community should pay great attention to it and explore if nuclear waste is comparable to CFC or if it is something different. Is it a by-product of generating electricity that requires one to consider alternate forms of generating electricity and whatever wastes or emissions they have? I think this is an important issue that was not fully developed.

There was a great deal of discussion on risk communication. I found it notable that in a number of papers there was a recognition of reverse priorities. By this I mean the technical experts in many nations will say: “here are the dominant risks. Here are the important issues to consider.” The public in those same nations have the list upside down or reversed. They perceive other risks as the being the most important. They perceive different priorities. This raises the serious question of social polarization. The idea that insiders have one view of the activities and one set of principles, and on the outside, the political system for example, there is a different set of views. This could be an impasse. I will speak here for the United States where we have a large body of people who argue that since “we are at an impasse we should make a decision based on being at an impasse, to stop trying to find solutions for the safe disposal of waste and to stop the generation of waste. Only later should we come to grips with the idea of disposal; let us set aside the fact that the waste exists in large quantities.” This is a very important issue and the theme of risk communication we heard yesterday brings that issue to a high level of importance.

The current safety norms, if I turn to the next body of views, do not simply concern safety criteria, such as acceptable levels of radiation exposure for the future, it also concerns the underlying principles of judgement. Fred Root’s paper had three “world views” constituting a sort of frame of mind, a philosophy for making decisions. Others enunciated principles (ethical, moral and environmental) for decision-making. I think it is very important we hear and listen to those views so as to recognize what should be our basis for judgement and to determine what should be the guiding philosophy in making decisions today that will affect the world for many generations.

There is, of course, a focus on future safety, safety in the narrow sense. Is radiation exposure from leakage of any waste repository acceptable? A fair argument was made by Dr. Ahearn who stated that in our focus on future generations, at least in the United States, we are tending to ignore the needs of the current generation. That is not a safety need. In the U.S., the issue is not that the safety of the people of Las Vegas from radiation is at stake, but the other impacts on those people. It is their ability to decide their own fate. There are many impacts on the current generation that should be kept in mind and not merely when looking at future generations. However, when looking at future generations we heard that in general the issue concerns less radiation exposure levels, or that exposure radiation level is an important choice, but uncertainty. How sure are we? How certain are we that we can estimate to a reasonable degree the impact on future society of leakage from the repository? That of course brings us to the earlier RWMC collective opinion on our ability to estimate.
Another issue that came up a number of times, and to my ear did not come up with rightness, was not addressed fully: **why retrievability?** We often hear we must have retrievability, but why do we have it? I heard yesterday that we must have retrievability because we may have made a gross mistake. If you must have retrievability because a gross mistake has to be reversed, the issue then is how long must you have that retrievability? Any reasonable choice of a repository would leak very slowly. This is a significant issue, to ask "Am I conducting retrievability or maintaining retrievability because I fear a mistake?" Or rather, and I think more will come when we hear the Dutch paper, are we maintaining retrievability to prepare for an alternate programme decision? To keep the options open? If society decides there is a better way to go, a better conduct of operations, recycling, etc., I think it important to address that issue specifically to make that distinction.

Lastly, on **intergenerational cost/benefit**, as far as intergenerational discounting is concerned our visiting advisors told us that if you look at personal judgement the world over, people will heavily discount future benefits. They will write off or discount in a very few years anything of significance. A society tends to take a longer view. If one is trying to discount with an interest rate, society will tend to take a lower discount rate and carry a greater balance for the future. Since we are facing a decision over so many thousands of years, I think the advice we heard was to avoid discounting. Discounting will wipe away the significance, the meaning, of any adverse impacts far in the future and it will confound the process; it will not help to make a decision. When I say "avoiding discounting", I think I heard: "just don't do it if you can possibly avoid it."

On balancing discounting, and this is something of a corollary, it is extremely difficult where you can do things in a quantitative fashion. Therefore, balancing quantitative considerations is difficult. However, balancing is even more difficult with what one may call the qualitative issues such as denying future generations alternatives or imposing judgements that we make today that they may not be willing to make.

We also heard in this context of possible approaches, such as sustainable development, what Professor Catron suggested as the concept of the "rolling present." Yet, I did not hear a clear and useful set of principles whereby we could make judgements about sustainable development that were pertinent to the very long range issue of nuclear waste.

To close, I would like to summarize what I think is a great concern. It has nothing to do directly with intergenerational cost/benefit, but rather with the decision making process and whether being at an impasse is a reason or a basis for decision. There was an analogy made by Mr. Thegerström who said: "let us consider this as an automobile where the developer, the industry, is the motive power. The regulators are the steering and the public are the brakes". That analogy betrays a polarity, and perhaps an impasse, in that the industry and the regulators are trying to go forward and the public is trying to stop. This is a very great concern. As we sit, and I think the Committee represents the motor power and the steering, and try to consider these ethical issues, how are we treating the brakes of the car? In many countries this appears to be polarized.

In his paper, Colin Allan had a pair of viewgraphs to illustrate who is involved. The first part of it was the industry and the regulators, in short the Establishment. The second page was a continuation, but it was the second page, the politicians and the public. This issue of polarization, of separation, is something I think we have heard very clearly yesterday. It must be given serious consideration.
GENERAL DISCUSSION

Dr. Flowers

We now have ten minutes for discussion on whether the main issues have indeed been identified, in judging whether the strategy for radioactive waste management is ethical and environmentally friendly. The floor is open.

Mr. Morgenroth

I thought that was an excellent summary, but it triggered two thoughts I had last night about some elements that were possibly missing from the discussion. The first element deals with the issue of minimization and prevention and the question of: “should prevention be a choice?” One of the things I have not heard in this strategy is the life-cycle approach going as is being used in the chemical area. It would involve consideration of the importance of nuclear power itself as an alternative to burning fossil fuels in terms of future generations, in terms of equity, and, also, in terms of the substantial benefits with regard to global warming issues that Bill Long talked about. These longer term issues, such as whether fossil fuel be saved as a starting material to make pharmaceuticals rather than being burned up in an irretrievable way, are at present critical issues for the environmental community. Maybe it is the sensitivity or the risk aversion of the nuclear industry that they are actually talking about the importance of nuclear power or potential importance in the context of these other issues in terms of both balancing and future generations.

The other issue I missed, and maybe it relates to some of the things Dr. Ahearne said, is the risk as well as the methods for handling the transport from present storage ponds of the radioactive waste material to the final disposal place. I wonder whether that does not factor in a number of areas and places, particularly in terms of risk to present generations.

Dr. Röthemeyer

In line with Dr. Morgenroth, I think that I missed the mentioning of the ethical requirement of balancing or weighing the advantages and disadvantages. This, as far as I understood the discussion yesterday, cannot be narrowed to the nuclear field only, but it has to be expanded and extended to the alternatives. This is a very important point because it gives a lot of responsibility to the technical people to do that in a concise way.

Secondly, I would like to discuss how a repository has to be looked at within sustainable development. Can it be valued as a deposit of resources or is it a disadvantage for the future? In the discussion presented by Mrs. von Rehn, we could get the impression that mercury deposit is a disadvantage for the future. It could possibly also be an advantage if in the far future we make other uses of mercury.

So what is a repository for chemical and nuclear wastes in the long-run? How could we value a repository?

Dr. Ahearne

I would like to make two points on what was just said by Bob Bernero. One I disagree with him that there is not a push within the industry to look at alternatives to producing the wastes. I think you began to mention, Bob, the industry, at least in the United States, is the electric utility industry. There is presently within this industry a major push to do without nuclear power, to go to gas turbines, to go to combined cycle plants, to go to solar, to go to a variety of sources other than nuclear power.
So I think the industry has definitely taken a step to do without producing nuclear wastes, although I would agree with you it is probably not primarily for that reason.

The second point refers to your closing statement. You made reference to Colin's charts and also talked of the difference between the technologists' list and the public's list and used the phrase "the public has the list upside down." Perhaps it is we technologists who have the list upside down. We at the National Academy of Sciences did a study a few years ago which looked at communicating risk issues and we learned lessons that all technologists ought to understand; that is, most of these disputes having to do with the public and the technologists coming up with separate lists are a dispute about inherent values and not about the facts. I mention in my paper a case in Taiwan where there was an extensive public programme to explain why a new nuclear power plant was needed. The polls made before and after the campaign showed public opposition to this facility. After the campaign, the public was more opposed than they had been previously, although the campaign itself was put on by the utility industry. The disputes are not necessarily about the technical facts, the disputes are about values. For example, fairness, the ability of a local community to decide for itself, and those kinds of issues.

Dr. Dejonghe

The following is on a slightly different point. Bob Bernero mentioned in his very clear presentation something about discounting which is perhaps a little bit too sharp. He used the word "avoided". I wonder whether we should not make, and maybe we do it automatically, a distinction about discounting for expenses we know we are going to have and which, although they might occur in fifty or one hundred years, we know they are coming. We would then discount by taking into consideration all the uncertainties which might arise in, for instance, ten thousand years; I am taking the two extremes. I fully agree with the conclusion to avoid discounting insofar as it refers to the very, very long term. On the other hand, the discounting for the acknowledged costs which we know are going to occur is current practice and I don't believe we can avoid that.

Dr. Flowers

While we are on that subject, can I just suggest there are another couple of questions concerned with the provisioning of resources and assets to generations many decades downstream. Perhaps I should express them like this: I am not sure that over a hundred years or more the provision of money in a bank account is an asset that compensates a physical liability even if the amount of money is right.

Secondly, it will become increasingly difficult over periods of a hundred years or more to make a realistic estimate of the cost of doing a physical task. Changes in regulatory standards, changes in engineering capability, have made huge differences in the decommissioning cost estimates, for example, of some of the UK reactors over the past ten years. Those two uncertainties seem to be issues that come in over the long-term discounting and provisioning.

Mr. Allègre

Je souhaite revenir à la discussion précédente qui s'était amorcée de manière tout à fait intéressante mais, me semble-t-il, sur un sujet qui n'est pas exactement le nôtre aujourd'hui. Nous sommes là pour parler des problèmes d'éthique concernant les déchets nucléaires. Or, la discussion telle qu'elle a commencée, me semble-t-il, était une discussion passionnante mais beaucoup plus large sur l'éthique de l'industrie nucléaire: fallait-il une industrie nucléaire ou pas, fallait-t-il faire du charbon au lieu de nucléaire, et autre. Je pense que cette question est fort importante, mais que ce n'est pas celle que nous devons résoudre aujourd'hui. Alors je ne voudrais pas que nous dévions trop de ce point là.
En ce qui concerne les déchets nucléaires proprement dits, ils sont là et ils doivent être gérés. On a souligné que dans un certain nombre de cas on a abouti à une impasse parce que justement on avait une très grande disparité entre ce que pensait le public et ce que pensent les experts. J’avais essayé hier de donner un certain nombre de raisons pour lesquelles la peur du nucléaire s’était transférée sur la peur des déchets nucléaires, et comment on pouvait expliquer cela. La réponse, et la seule, c’est d’expliquer davantage et montrer au public que les déchets nucléaires, par exemple, ne sont pas des déchets du type Tchernobyl qui provoquent des retombées à partir de l’atmosphère; que cela n’a rien à voir avec la bombe atomique, que ça n’explose pas; que c’est sous forme solide, etc. Ces explications extrêmement simples permettront déjà d’éviter un certain nombre de réactions épidermiques qui sont, j’en suis persuadé, celle de la plupart du grand public qui n’est jamais suffisamment informé dans ces matières.

Quant à la question de la réversibilité soulevée à nouveau par M. Bernero, je suis tout à fait d’accord avec lui que si on était persuadé qu’il devait y avoir une importante fuite dans un stockage souterrain, et bien cela ne serait vraiment pas la peine de faire le stockage. Quant aux raisons d’une éventuelle réversibilité pour ma part j’en vois deux. L’une c’est de pouvoir dire à ceux qui nous répètent sans cesse “ne faites rien, attendez que la science fasse des progrès et résolve le problème”, que si par hasard dans les quelques dizaines d’années à venir la science fait ces progrès immenses qu’ils espèrent, et bien nous pourrons toujours reprendre des déchets dans le stockage. L’autre raison est purement politique, elle est purement factuelle: c’est pour atténuer en quelque sorte ce sentiment de l’irréparable qui participe à la peur considérable, signalée tout à l’heure, dans le grand public à l’égard des déchets nucléaires.

(I would like to return to the preceding discussion which began interestingly enough, but which did not concern, it seems to me, today’s topic. We are here to discuss the ethical problems concerning nuclear wastes. Thus, although the discussion such as it began was fascinating, it dealt with the broader ethical issues of the nuclear industry: was nuclear industry necessary or not; must one use coal rather than nuclear energy, and so on. I think these questions are very important, but they are not the ones we must resolve today. So I would appreciate that we not deviate too much from our subject.

Nuclear wastes exist and they must be managed. We have stressed that in a certain number of cases an impasse was created because of the disparity between public and expert opinion. I attempted yesterday to give a certain number of reasons as to why the fear of nuclear energy has been transformed into a fear of nuclear wastes and how this can be explained. The answer, and the only one, is to better explain and demonstrate to the public that nuclear wastes are not, for example, similar to the radioactive fallout caused by Chernobyl; that it has nothing to do with atomic bombs, that it does not explode; that it is in a solid form, etc. These very simple explanations would help us to avoid a certain number of emotional reactions which are, I am sure, typical of a public not sufficiently informed on the subject.

Insofar as the question of retrievability is concerned, and which was raised once again by Mr. Bernero, I wholly agree that if we were convinced a leak would inevitably occur in an underground disposal facility, then there is no reason then to build that facility. I see two reasons as to why retrievability might be necessary. First, we must have the possibility to say to those who repeatedly insist: “do nothing, wait for scientific progress to resolve the problem", that if science should happen to make such immense progress in a few decades from now, well then we can always retrieve the waste from the repository. The other reason is purely political, purely factual; it is an attempt to attenuate this great fear of irreversibility which characterises, as indicated earlier, the public’s perception of nuclear wastes.)
Mr. Roots

I would like to add a comment to those made by Dr. Röthemeyer and Dr. Dejonghe about whether there were some aspects that we didn't consider yesterday in looking at the ethical issues concerning waste disposal.

We have tended to look at the waste disposal question in isolation from other polarized issues that the public at large is dealing with, although part of this was dealt with by Dr. von Rein. I think that there are other related issues that this same public in discussing or expressing opinions on nuclear power is also concerned with and which we need to have comparisons with. For example, large hydroelectrical developments. As far as the public is concerned, a valley that is flooded is irretrievably changed from where they used to make their livelihood, and so on. There are some utilities that have quite a lot of experience in doing such things as trying to consider what is the investment required and how to discount it for expenses they have incurred and revenues lost due to changes in population and things like that. The whole area of putting the controversy about nuclear waste in perspective and in proportion with other controversies that the public and the authorities are worrying about is something we didn't really open up yesterday.

Dr. Flowers

That is a point which I was hoping would be made because although we are trying to pioneer a careful consideration of ethical strategies in the field of radioactive waste disposal, we should not deceive ourselves that this is the biggest liability which is being left to future generations.

Dr. McComble

I would just like to pick up on this comparison with the environmental aspects of minimization and recycling which Bob Bernero picked out from Victor Morgenroth's paper. I was also astonished yesterday at the numbers, but the thought that came to me was: "have we been sleeping?" I should remind you that in this industry, ten, fifteen, twenty years ago, minimization and recycling were the big positive environmental issues. We did not lose sleep, as people do today, over the enormous quantities of radioactive waste sitting around. We were very proud that radioactive power generation produced very small quantities of radioactive waste, which it still does today relative to the amount of energy produced. We have a positive balance there.

The other aspect, which was also viewed as a very positive environmental issue, is recycling. Recycling was justified as an ethical way to use natural resources in an efficient way. Now the opponents of nuclear power look on recycling as the devil's own work and the worst part of waste management. In some ways, the presentation of the statistics were very striking. It makes me think not that nuclear radioactive waste disposal is particularly bad in this way, but that maybe we have been letting up on our duty of emphasising some of the inherent advantages which were recognized when this technology was first introduced.

Mrs. Greber

I would like to get back to the point about the impasse between the public and the technical experts that Mr. Bernero brought up. The important point is that an impasse should not be a reason for not making decisions.

I am sure that a lot of you are familiar with the work that has been done in the area of public perception versus technical evaluations of risk. Paul Slovic, for example, talks about things like controllability and voluntarism, and things like that. I think the industry can look at ways at adapting the technology, at adapting the disposal concepts in its plans for implementation to correspond to the
kinds of values that society is expressing: values that various sectors of the public are expressing to us as being important to them as part of the decision-making process. We have seen examples in practice in Sweden and, in some cases, in Canada, where we have been able to successfully site facilities that people normally do not want in their backyard. If we look at the kind of values people are expressing we find they want to have some kind of control over the facility, over the decision that is made; they want to ensure safety because that is the number one priority.

I do not see as much polarization between public views and the industry's views when it comes to the essential issues. We can look at the possibilities of leaving the facilities open for a period of time until society feels comfortable. We can include the option of reversibility into the disposal technologies. We can look at things like voluntarism as a means of being able to site facilities. We can look at fairness of due-process. We can look at the kinds of benefits that society, or communities, want for being host to the facility. We can look at the whole issue of trust as the way that we implement the technology or our plans for implementation and how we can adapt the technology to be able to correspond or match societal values.

Dr. Flowers

I hope that Bob Bernero got some further ideas from that discussion. I would like to move on to Topic B and Charles McCombie will summarize that for us.
Disposal Objectives: Are they Fair and Properly Defined?

Charles McCombie
NAGRA
Switzerland

I was asked to make some connections between the ethical issues that are presently being discussed and the objectives and the principles which we have espoused today in the nuclear waste disposal area. I tried to group it under the following set of questions:

- Are the objectives and principles which we espouse properly defined?
- Are they sufficiently complete? Have we missed any out? Did we make any additional suggestions?
- Are they fair when we measure them against these ethical principles?
- Are they too ambitious? Are we going too far in one direction?

These are the questions that I am going to try to answer along with those concerning the objectives and principles we have today. The place where these objectives and principles are best or most concisely stated are probably in the following Safety Fundamentals, which I am sure almost all the insiders know that are being produced by the IAEA. These are the agreed set of overall objectives, which are appended to the background material:

1. Acceptable level of protection.
2. Protection of the environment.
4. Level of protection in future.
5. Undue burdens.
6. Leave options for future generations as open as possible.
7. Develop an incremental, transparent procedure involving public participation.
8. Minimization and recycling.

The first five of these I have called ethical principles. We want to protect health today to an acceptable level. We want to protect the environment. We want to protect beyond national borders. We want to protect future generations to the same level that we would expect to be protected today. We do not want to place an undue burden on future generations. The other principles, 6 to 9, are what I would call system-oriented principles that are more concerned with developing a waste management system, although they do include the minimization issue.

If I look at these five ethical principles and try to make a connection to some of the points that have been made today, one point we could perhaps make is that we can protect people today at an acceptable ethical level without disposing. We all know we do not need higher protection today. We
can keep wastes on the surface and provide adequate protection. The other point has to do with how levels of protection are determined and whether the levels of protection in force are not too stringent? These are two closely related ethical issues, but I do not want to spend any time on them.

The protection of the environment involve two issues which sometimes trouble me. We want to protect the environment and in our principles we claim that by protecting man we protect the environment. Everyday I read that statement I have a funny feeling in my stomach. I do not know how true it is. I know that in other areas like hydro power production it is possible, at least for frogs, to leap straight from a hydro dam to an endangered species without going through the agency of man. So I am not sure how defensible we are with our protection of the environment there. Another grey issue is resource protection. How much do we have to do to protect resources in the future?

The protection of national boundaries is a good ethical point and there is no debate on it except, perhaps, for the international solution. There is a tendency to assume that the only ethical thing to do is carry out all disposal within your own boundaries. Several countries, including Switzerland, have legislation which goes very strongly in this direction. It is my personal opinion that this is not an important ethical issue, but I know this is not shared by many other people. These are relatively brief comments on the first three principles.

The level of protection we want to provide in the future is an element of the intergenerational question. Should we favour the near future over the far future? That we do not do this is a highly ethical point. It seems clear that our objectives today are based on the belief that today's values will be the same ten thousand years hence. This seems to me a very unusual position. I should point out that because of the very technical nature of a waste disposal programme, we will be giving a higher level of protection to the near future generation than to far future generations. The system will work. John Ahearn said it very clearly: it will work for hundreds if not thousands of years. So there will be a higher level of protection in the near future. But that is not our intent. We cannot deliberately make it leaky at the beginning to be equitable to future generations.

This level of protection is then higher for the many future generations, but the ethos behind it is that we are not doing it deliberately. This is expressed in our expectation that risks left for generations in the very far future to deal with would only be those considered acceptable today. That is a very strong ethical position. However, this leads to some ethical considerations concerning what I would call "time bombs". By this I mean a system that stays totally safe for a long time before anything happens. This delay effect is very worrisome to the public.

The last point concerning protection of future generations was mentioned yesterday. We don't just pass on disadvantages, we pass on benefits as well and we tend to jump over these. I personally feel very strongly that I would rather leave my children's children a well-organized waste repository next to a non-depleted coal or oil-reservoir than no waste repository and, also, no oil or coal. There is a connection here: we first bestow benefits as well if we do it right.

The last point concerns undue burdens. The question that came up yesterday is: how far do we have to go towards implementation while still leaving options open? As I mentioned yesterday, there are three relevant arguments for deliberate delay. We can delay because we hope for better technology, because it is economically sensible to do so, and, finally, we can delay for reasons of political or social peace. All of these have ethical issues attached to them. We will come back to this later on today.

These are my comments on the five ethical principles declared to be the principles of current waste management policy. There are potential additions such as the "leave options open for future generations" which in the last three years has been increasingly raised to the level of a principle, although it is still not explicitly stated in our current set of principles. Of course, leaving options open
conflicts with principles 4 and 6 and it conflicts with the burden issue by leaving work open. It could also conflict with the protection issue if we leave options open by doing things which decrease the safety level. When we can leave options open we can do so in two ways. First, by surface storage and secondly, through retrievability. There are different measures for different cases as to how much work you may leave the next generation.

Another principle, as was clearly mentioned in Colin Allan's paper, should be to develop an Incremental, transparent procedure involving public participation. We all believe in this and know it to be the case, but we do not state it clearly. It is not, for example, explicitly included in the principles. Transparency means listening and this brings you to the upside-down priority list. What do we do if we think somebody has their priority list upside-down? Do we leave it and accept it and try to do something, as Bob Bernero said, or do we try to reach agreement, or do we accept what the public wants? A decision must be made.

The other public issue mentioned in the background document, but not discussed so far, is the compensation issue. It is fair to say that ten or fifteen years ago there was a feeling that direct compensation to an affected community was not ethical. Everybody kept their hands off; it was sticky and a little bit dangerous to get into. Then came a time (starting, I think, in the United States where there is a longer history of that kind of negotiation) when people discussed compensation for a Monitored Retrievable Storage (MRS) facility or for a repository. Then came the French position with Mr. Bataille. In Switzerland, we have also negotiated a deal and it would be interesting for us to know how it compares to other communities. There has been a swing from nervousness about the ethical implications of compensation being equivalent to bribery to compensation being a normal thing. I myself would expect compensation if a waste repository was in my home community. So I think an ethical change has developed here.

I have already mentioned minimization and recycling in one of my comments and will not go into it further.

The last point, concentrate and confine and not dilute, also mentioned in Colin Allan's paper as being the industry standard, is a good principle. I am not sure, however, it is always the right one. One example would be Iodine 129. We do the most stupid thing we could possibly do: we take Iodine 129, which is a harmless substance by any normal measure; it has a half life of 17 million years; we collect it from all over the world; we put it in bottles and get terribly worried. We have done a risk concentration procedure which is not an obviously ethically correct thing to do. In Sweden, they have done the same thing with mercury. Out of the ground and back into the ground is wonderful: what came out the ground distributed and diluted is put back into the ground in a concentrated form. What you are doing is transferring the risks, an intragenerational shift in the risks, from a widespread thing to a narrow thing. Is CC rather than DD at the level of a principle? If it is, what is the ethical justification for this principle?

The very last point is: are we being too ambitious? We may very well be trying to be too ambitious and some indicators could be useful here. The cost of disposal in round numbers are hundreds of thousands of US dollars per ton for spent fuel. That is a lot of money per unit. On the other hand, it is only three to five per cent of the kilowatt/hour price. Are we spending, then, very much on this job or are we spending very little? It depends on your perspective.

The next point also concerns the question of being too ambitious. 0.1 millisievert per year, is a kind of standard number, for ten thousand to a hundred thousand years. This is a factor of ten to twenty times better than nature can do for times in the future that nobody has talked about anywhere else before. That is really ambitious. Mostly we do not worry about concentration of toxic substances until we get up to natural levels. Here we are way below them and want to regulate them for a long time ahead. That causes a lot of scepticism if not disbelief in the scientific community outside our own.
Are we being too ambitious, do we have too much irrelevant R & D? We do some crazy things in technical areas. We measure rainfall in Yucca Mountain to a tenth of a millimetre per year when what we really want to know is the rainfall in Yucca Mountain averaged over a thousand years, ten thousand years, down the road. I am sure that we over exaggerate sometimes.

I think it is really good that the Radioactive Waste Management Committee has a wider forum for this meeting here. It gives a different perspective and I would like to hear and know more about what happens technically in other areas, including the ethical aspects.

The very last question that I wanted to finish off with is maybe a very relevant one today. Is it ethical for fifty people to sit here for another two days talking about ethics? Do other people do it?

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GENERAL DISCUSSION

Dr. Flowers

That was a good résumé of the very considerable and perhaps ambitious and exaggerated objectives which the nuclear industry has set itself for the management of these long-lived radioactive wastes.

Dr. Röthemeyer

I would like to encourage comment from our colleagues in ethics. Therefore, I would like to take up a thought presented by Charles McCombie. He mentioned one millisievert for ten, hundred thousands of years. In the very long run, we cannot guarantee isolation of the wastes and in this very long run the concentration of these hazardous materials exceeds all concentration of hazards in nature. How do you look at that? Do we have to balance the advantages and disadvantages of different technologies? This is not limited and restricted as one may think to nuclear wastes, but refers to other wastes as well. What is the answer to that? What will change in the very long run when we cannot guarantee isolation any more? The environment will probably never go back to its natural state or, if it does, it will probably take a very long time.

Dr. Flowers

I would just like to add that in making that last point that radioactive material will never go back to its natural concentration, you have made the point that, in many cases, it will never escape from where you put it.

Dr. Röthemeyer

I think in the long run it will dissipate all over the place and become part of the natural cycle of matter. However, it will change this same cycle.

Mrs. von Rehn

As we have been talking of ethics, I have been asking myself "what have we really been talking about?" I see our proposal concerning deep geological depository of mercury waste more as an ethical question: we have the waste now because we have been using the mercury, which we have decided to no longer use because it is such a threat to nature. The question now is: what are the different options for the disposal of this waste? This concerns more ethics than the level of ambition. Is deep geological disposal more ambitious than surface disposal? It is really two things: level of ambition and responsibility to take care of the wastes we have produced.

Dr. Ahearne

I would like to comment on Charles McCombie's compensation issue. We have had for over forty years in the United States the concept of what we call impact aid. This was developed because of the many large facilities, such as military bases, and the large Department of Energy facilities, at that time the Atomic Energy Commission. The people who work at these places use police, fire, schools, and other local communities services. So our Government came up with what they termed "impact aid", which were funds provided to the local communities as compensation for having these large government facilities.
It is this same concept that has been applied in discussions with local authorities about accepting a waste repository. The debate has turned, however, to environmental justice questions. The issue that has now been raised is that the communities that seem to be more interested in taking these hazard-type sites are those that are very poor; places where jobs have been lost, where poverty is greater than in other communities. There is, consequently, the suspicion that these communities are willing to accept these sites and take this assistance because they are poor. This has raised the concept of environmental justice and the issue is now being debated as to the fairness of imposing this kind of a hazard, whether it is a chemical waste or a nuclear waste site, on a community merely because it is poor. The ethics that are now being debated is how to determine who are the right people or organisations to make such a decision? The local poor community at times has said to want a particular site and other organisations have reacted by saying: "it is unfair, you should not have to take that site." It is a confusing situation.

Dr. Flowers

We heard yesterday Mrs Gundelach say that you should not necessarily equate the current society view with what is ethical. Perhaps this is an example.

Mr. Morgenroth

I would like to try to answer two questions and raise one concern. In terms of compensation in the chemical field there is a move towards establishing compensation schemes for the siting of facilities and for past damages caused by a facility. Some governments have, in fact, built that into their policies. In Japan, for example, there is quite an extensive compensation scheme associated with past exposure to methyl mercury. This is true in more and more OECD countries.

In one of the areas, there is a move to set up a workshop to look at fees and other kinds of things associated with siting of hazardous installations and whether or not these installations should involve compensation schemes for emergency response planning, for providing fire and other facilities that may not have been necessary had those facilities not been sited in a particular place.

The other issue is associated with your first slide. I would almost phrase this issue as a risk communication problem that your group may have relative to the environment community. When you talk about safety norms and adjusting things to the levels of today's requirements over longer periods, in fact most people in the environment area recognize that standards become more stringent with time. In the chemical field that which was considered a safe level five or ten years ago, is considered today to be unacceptable because of the better data in chemicals we are now obtaining. I think it is important you attempt to explain to the public that the data and safety norms you are talking about are based on relatively well-established data gathered over a long period. The uncertainty associated with your present norms is not similar to the certainty associated with norms or established acceptable daily intakes for substances because of the more modern technologies and animal bioassays for the advent of more molecular biological approaches. Obviously, as the methods and sensitivities of those methods become high, the standards become lower.

You have a complicated issue and there are problems in explaining it to the environmental community. You should recognize that because the first point to most environmental people seems totally backwards, the future will demand greater and greater safety norms. I think this is an important issue to consider as you attempt to communicate this information.
Dr. Zurkinden

The reason we are here to discuss ethics lies in the fact that the general public does not believe that safe and permanent disposal of radioactive waste is possible. I thought that we in this community were convinced that we can achieve the objectives listed by Charles McCombie. If not, there is a need to discuss and see what one can do with the waste. However, if we are convinced we can meet these objectives and that safe and permanent disposal is possible, then we better try to understand why the general public does not believe in this fact and concentrate our efforts in convincing the public.

Mr. Alexandre

Je voudrais revenir au problème de risques parce que j'ai l'impression de temps en temps que les échanges et les discussions que nous avons prênnent un tour discutable. Je crois qu'il est tout à fait normal de réfléchir sur le niveau des risques et d'acceptation du risque dans la société. Mais c'est une évidence que tout le monde a déjà énoncée "on ne peut pas vivre sans risque." Faire croire à la population, et en particulier dans l'énoncé d'une opinion collective, que l'on peut supprimer tous les risques me paraît extrêmement dangereux. Les Suédois ont pris une décision tout à fait admirable en disant qu'ils n'utiliseraient plus de mercure, mais peut-être que le mercure, dans certains cas, on est obligé de l'utiliser. Ce qu'il faut, c'est évaluer les risques.

Par ailleurs, il a été évoqué tout à l'heure le fait que lorsque les confinements des déchets radioactifs se dégraderont, la conséquence sera le relâchement dans la nature d'un certain niveau de matériaux à des concentrations différentes de celle du naturel. Je crois que ce n'est pas forcément un drame. C'est quelque chose que nous devons évaluer. Mais quant à modifier la nature, l'homme est une création de la nature et depuis qu'il est sur la terre il ne fait que cela. Il continuera certainement encore longtemps.

(I would like to come back to the problem of risks because from time to time I have the impression that our discussions might be moving in the wrong direction. I think it is perfectly normal to reflect on the levels of risk and what level of risk will be accepted by society. It is clear to everyone, however, that risks cannot be totally avoided. To try to make the public believe, and particularly by way of a collective opinion statement, that we can eliminate all risks appears to me to be a highly debatable position. The Swedes have taken the admirable decision to stop all use of mercury, but perhaps the use of mercury, in certain cases, is necessary. One must be able to evaluate risks.

It was also mentioned earlier that radioactive waste containment barriers will eventually deteriorate and will consequently release materials at concentration levels different from nature's. This is not necessarily a serious situation, but one which must be studied. Insofar as modifying nature is concerned, man, who is a creation of nature, has done only that since he has been on earth. He will certainly continue to do so for a long time.)

Mr. Allègre

Dans son très intéressant exposé, M. McCombie a signalé de nouveau la question: faut-il laisser l'option ouverte pour les générations futures? Ensuite, un point a été soulevé de nouveau sur la question des taux d'actualisation en disant que peut-être on peut les garder pour les périodes proches. Je crois que ces deux sujets amènent à faire un distinguoc entre ce que j'appellerais le futur, c'est à dire le futur éloigné, les fameuses générations futures dont nous parlons toujours, celles qui existeront dans dix mille ou cent mille ans, et, d'autre part, le futur extrêmement proche, que j'ai tendance à appeler le présent et qui peut être aujourd'hui ou les 50 ou 80 années à venir. C'est pendant ces 50 ou 80 années à venir, pendant cette période présente, que nous avons précisément à nous
engager dans une voie qui intéressera les générations futures dans dix mille ans. C’est là que se pose le problème d’éthique.

La question de savoir si nous prenons la décision, dans dix ans, dans vingt ans ou dans trente ans, a quand même une importance très faible par rapport au sens du bilan dont nous parlons. Libre à nous de tenir compte de toute l’actualisation possible si nous voulons pour examiner les situations pendant les trente premières années, de même qu’on peut envisager une forme de réversibilité limitée aux premières années pour les raisons exposées tout à l’heure, mais de toute façon nous n’éviterons pas dans le présent de prendre des décisions qui impliqueront le futur. C’est là que nous retrouvons le problème d’éthique.

Ces décisions à prendre aujourd’hui ne peuvent être prises que suivant une méthode pas à pas, que Colin Allan avait signalée hier matin dans son introduction et que nous avons retrouvée à chaque pas, si je puis dire, dans nos discussions. Nous sommes tous, sous des formes un peu différentes, engagés dans un processus de ce genre et ce qui serait grave serait de ne pas progresser dans ce processus, même si ce processus est long à l’échelle humaine. Il faut travailler avec le maximum de rapidité, d’efficacité aujourd’hui pour avancer dans ce processus. Cela prendra du temps et de toute façon nous aboutirons à un compromis. Cela sera un compromis entre ce que nous diront la science et la technique; entre ce que penseront les politiques et ce que pensera, finalement, l’opinion publique. Mais pour arriver à ce compromis il faut du temps et ce temps c’est du temps présent.

Cela étant, je pense aussi que nous allons trop loin dans l’ambition mais après tout c’est peut-être le prix que l’industrie nucléaire doit payer aujourd’hui pour être crédible et pour que les solutions retenues pour les déchets soient crédibles auprès du grand public.

(’Dr. McCombie, in his very interesting presentation, brought up once again the question: must we leave options open for future generations? A point was then again raised on the question of discount rates by stating that we could perhaps use them for the short-term. I think a distinction must be made on these two subjects, between what I would call the Future, that is to say the long-term future together with the generations which we are always talking about and that will exist in ten thousand or a hundred thousand years from now, and, on the other hand, the relatively short-term future, which I have a tendency to call the present, but which can refer to today or the next 50 or 80 years. It is during these 50 or 80 years to come, during this present time period, that we must begin the process that will concern future generations ten thousand years from now.

The question of knowing if we must take the decision in ten years, in twenty years, or in thirty years, is of relatively little importance in relation to the assessments we are discussing. We are free to take into consideration any discounting method to study situations for the next thirty years, just as we can envisage a form of limited retrievability for the first few years for reasons discussed earlier. But we cannot avoid making decisions in the present that will affect the future. We are confronted once again with the problem of ethics.

The decisions that must be taken today can be done so only by using a step-by-step approach, mentioned by Colin Allan in his introductory speech yesterday morning, and which we have encountered at each step, if I may say so, of our discussions. We are all committed to more or less this same type of process and it would be a serious thing not to continue with it even if on a human scale it is a very long process. We must work as rapidly and efficiently as possible to make progress. This will take time and, at any rate, we will have to make a compromise. What kind of compromise? It will be a compromise between scientific and technological considerations; between politicians’ views and, finally, public opinion. Time is necessary in order to arrive at such a compromise and this time is the present time.
This said, I think we are too ambitious, but this is perhaps the price the nuclear industry must pay so that they and the waste solutions retained are credible to the public.)

Mr. Berkhout

I wanted to respond to a comment made twice this morning that one needs to take into account the benefits as well as the costs that have been bequeathed to future generations and that this would lead one to proceed with a much larger systems assessment than the rather restricted one which we are concerned with here. I wanted to provide a slightly different angle.

It seems to me that there are possibly three kinds of indirect benefits which we provide to future generations through the production of nuclear power. The first is obviously the technological heritage. We have developed technology that they too may be able to use. The second is that we avoid other types of environmental costs and obviously the one highest in people’s minds is carbon emissions and climatic change. The third is that we provide power for our own more general economic development. That too is a benefit for future generations.

To see these unequivocally or unambiguously as benefits for future generations must be called into question. The first reason for that is that we are ignorant about future preferences. We do not know whether what we regard today as a benefit will indeed be regarded as a benefit by them. For instance, can we be sure that in a thousand years time that people will still be operating nuclear power reactors? Will that be a technology which they see as a benefit to their own welfare? I think more importantly than that, and this is in response to the question of carbon emissions, the reason why carbon emission reduction through nuclear power seems to be a benefit to us is because that is our choice as the way to provide electrical energy and provide savings in carbon emissions. Of course there are other ways of avoiding carbon emissions today. For instance, by being much more rigorous about energy efficiency or by developing different transport systems. In that sense, it is entirely our choice about how we structure these future benefits. We could have done it differently.

The benefits to us may not be self evident if it is to future generations. The burdens, on the other hand, do seem to be more likely to continue to be regarded in the future as burdens. It is obvious to us that health burdens and the burdens of management of radioactive waste will continue to be so in the future.

Professor Catron

I wanted to make a comment about the relationship between compensation and national boundaries. I think the issue of compensation illustrates beautifully how ethical principles often have to be balanced against one another. If you take the utilitarian approach which is either maximizing net benefit or minimizing the costs, as Dr. Gundelach discussed the other day, the notion of making some sort of a bargain where you put a repository in a poor community allowing them to gain in an economic sense is acceptable. This is the current situation in the United States where there is a consortium of energy companies negotiating with Mescalero/Apache Indians in New Mexico. To the tribal elders who are pursuing this project, it represents a hope for long term tribal independence and prosperity. They are interested in taking a temporary repository. From the other point of view, this smacks of environmental racism because by some principle of environmental justice, as opposed to utilitarian principles, there is a notion that protection should be provided against exploitation.

The way this works with respect to the international issue is in the anti-dumping provisions which prohibit moving toxic wastes into poor communities. However, the chief economist at the World Bank, Lawrence Summers, has argued that "underpopulated countries in Africa are vastly under polluted compared to large urban centres". Straight economic logic would say that toxic wastes should be moved to low-wage countries because the costs of pollution are lower there and so you minimize
the net costs. Mr. Summers stated that the economic logic behind dumping a load of toxic wastes in the lower wage countries is impeccable.

I would certainly not argue that. I think that there is a principle of distributive justice and fairness that should prevail. But by the same token I would not want to see the principle of disposal within national boundaries get in the way of trying to find international solutions to this problem. It seems to me that we might very well want to broaden or to relax the principle of resolving it within national boundaries in order to look for international solutions as long as that principle of justice is not violated.
Topic C
Implementation Strategies
(with emphasis on storage/disposal and timing of programmes)

Per-Eric Ahlström
SKB
Sweden

The strategies for treatment and final disposal of nuclear waste were very well presented yesterday by Colin Allan, so I will not repeat what he has already said. Although I believe that most aspects were covered in the previous deliberations, I will make a few comments on the implementation of these strategies which I feel are particularly important. I will restrict myself to the treatment and disposal of high-level waste from spent nuclear fuel from power reactors. These arguments are, however, relevant in many respects to other types of radioactive waste.

A part of all strategies is interim storage of spent nuclear fuel (and/or the high-level waste) for a short or long period. In Sweden we have planned for about 40 years of interim storage in order to simplify further treatment and disposal. Although I agree that having sufficient interim storage capacity is an asset for any national programme, I do believe that this is not enough for the future.

The two main strategies for management of the spent fuel can be summarized by the words: reprocessing and direct disposal. Reprocessing means that most of the fuel material is recovered for recycling. Today such recycling is implemented only for uranium and plutonium. Some efforts have been undertaken, in Japan and France for example, to develop recycling of other long-lived radionuclides. This is referred to as partitioning and transmutation because the prime objective is minimization of the amount of very long-lived nuclides in the waste stream. To achieve this one needs to develop new technology. Even if this development is successful, some long-lived wastes will remain in the waste stream. I do not think anyone believes that any one process will work 100%.

At present, the waste products from reprocessing are vitrified high-level waste (i.e. glass-blocks) containing some 95% to 99% of the radioactive elements in the waste. Considerable volumes of low- and intermediate-level wastes are also generated by reprocessing. It is important that all such waste streams result in solid materials conditioned for disposal.

The reprocessing strategy could be considered to be more in line with the principle of sustainable development than the alternative route of direct disposal. Direct disposal was introduced as a seriously considered strategy only when it became evident to some countries, for example Sweden, that many influential groups considered the use of nuclear power as a parenthesis in the development of power production strategy. Up to the mid-seventies reprocessing had been the only route considered. Today, direct disposal is the preferred option in many leading nuclear countries, including the USA, Canada, Sweden and Finland, and interest is growing in many other countries which only a few years ago were firmly committed to reprocessing.

The choice between the strategies of reprocessing and direct disposal is related to the balance of risks between present and future generations. A complicated treatment today implies a greater risk of plant workers receiving doses just as the disposal of larger quantities of long-lived radionuclides implies some increase in the risk of exposure to future generations. I am convinced, however,
that in this comparison the risk increase for the workers is larger than the risk increase for future generations. I do not think, though, that we are at a risk level that would be decisive in the choice between strategies.

It was also clear in the discussion yesterday that achieving public consent to implement plans for final disposal of long-lived wastes is as much a problem as the technical aspects are. The controversy surrounding radioactive waste is present at all levels of our society.

Implementation is approached in steps. I will give as an example an outline of the main steps we are planning to carry out in Sweden. The first step is finding a site. This involves both the gathering of geoscientific and other relevant data, as well as an extensive public information and education programme. It is important to maintain a high standard and quality for all of these activities in order to build confidence and trust.

The second step is to characterize the site and gather all necessary site specific data needed for designing a repository, for safety analyses of the repository and for obtaining the required construction and operating permits. This step is in itself a major task requiring its own permits and substeps.

The third step is the construction of the necessary facilities. In Sweden this consists of an encapsulation plant and a deep repository.

The fourth step is disposal of the waste packages and, before that, the encapsulation of the fuel. This is the first step where you will actually physically change the waste for disposal.

In Sweden we plan to develop the repository in two phases. The first phase has already started and will involve only some 10% of the spent fuel. After the first phase, we will make a full stop and evaluate the experiences and results from the first phase as well as parallel developments that have taken place in other countries or organisations before deciding on the second phase. The start of the second phase will require new permits. This approach will include the option to change course and even retrieve the waste packages for other treatment and/or disposal.

Coming back to the first step - the siting process - I think it is here that you set the ground for your credibility in ethical and environmental matters. It is not enough to have a technically sound case accepted by the authorities, you must also give the community the chance to express its opinion, to receive considered answers to their often valid questions, and to influence the process and the local implementation in a fair way.

The process of constructing the repository in two phases is an attempt to meet two principles:

- impose no undue burdens on future generations;
- future generations shall have the possibility to take control and exercise their best efforts and responsibility as well as we have that possibility.

In some 20 years time evaluation of the first phase will be possible. The people making decisions will have a waste repository in place and will thus have the means to do some monitoring. They will have acquired experience from siting, licensing, construction and early operation of the repository and other required facilities. They will also know what progress has been made in other areas of interest for the future of the spent fuel. They will have money in funds to deposit the remaining parts of the waste and the freedom to do something different if they want. It is their decision, not ours.
Using this approach avoids the concerns of many of today's political leaders when we ask them for a political decision. They do not want a decision that "determines the destiny of their community forever." There will be a way out if needed and someone else with 20 years experience or more may take the difficult decision. In my opinion a decision made at that time will not be felt to be so full of destiny because experience will have been acquired. On the other hand, if you postpone any action towards a final depository, I believe the decision to be taken will be more difficult and the feeling of frustration of the responsible "waste managers", the responsible authorities, and the political leaders/decision-makers will only escalate.

For the discussion, there are four elements to the implementation strategy that I feel are relevant from an ethical and environmental point of view:

1. It is important to do something that in the future will be looked upon as real progress;

2. It is important to take the necessary technical and political decisions in carefully planned steps;

3. It is important to accommodate legitimate concerns of those living close to the selected site. Work with the local population, not against them;

4. It is important to give the future decision-makers who must take some of the critical decisions some reasonable freedom of choice.

I would add as a final comment a statement by Richard Whately, Archbishop of Dublin some 150 years ago, who declared: "We are responsible not only for what we do, but also for what we fail to do!"

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GENERAL DISCUSSION

Mr. Letèvre

Je voudrais remercier Per-Eric Ahlström pour la présentation très objective, très ouverte, qu’il a faite des deux options du retraitement et du non-retraitement du combustible irradié. Je voudrais reprendre cet aspect du recyclage, puisque l’on parle de retraitement, mais on peut le présenter sous la forme de recyclage dans le cadre de l’éthique qui nous intéresse pour la gestion des déchets. On a déjà eu l’occasion d’en parler à plusieurs reprises, par M. McCombie, par M. Bernero. C’est un point qui me paraît essentiel au niveau de l’éthique. C’est vrai que l’idée n’est pas neuve, Charles McCombie le disait tout à l’heure. Mais il me semble qu’elle est mise en application de plus en plus largement et à un niveau qui touche beaucoup plus le public: celui des déchets urbains.

Je suis frappé qu’en France, un pays latin, on voit maintenant dans tous les villages des conteneurs pour le verre. Je sais que dans des pays moins latins que nous, ce sont deux, trois, quatre poubelles. Ma tille est actuellement en Allemagne et elle est affolée du nombre de poubelles qu’elle a à remplir et le tri qu’elle a à faire. Je crois que le recyclage des déchets est une idée qui répond à une conviction profonde du public; qu’il est possible de réduire la quantité de déchets non pas totalement, mais sélectivement. Il y a une idée d’économie qui est probablement fausse. On sait que les spécialistes, particulièrement les verriers, disent que le verre recyclé coûte plus cher que de faire du verre directement. C’est pareil pour le papier qui faut décolorer. Donc, cela est bien au sens de l’éthique et non pas de l’économie qu’on doit se placer dans cette idée de recyclage.

Le nucléaire ne peut pas y échapper. Nous devons nous préoccuper de voir quelles sont les possibilités de recyclage de nos déchets nucléaires dans cet esprit. Je ne cherche pas à défendre la position française, mais je crois profondément que c’est un devoir d’étudier ce recyclage. Nous devons être honnêtes et conclure, ensuite, ce qui est faisable raisonnablement, ce qui ne l’est pas. Mais nous devons au nom de l’éthique regarder toutes les possibilités dans ce sens.

J’ajouterais simplement que je crois qu’il faut préparer par cette voie la fin de la période du nucléaire de fission. Il me semble qu’il y a deux manières de la terminer. Il y a la voie du non-retraitement et je dirai que les générations futures des pays qui n’auront pas fait de retraitement, seront peut-être heureuses de l’avantage que notre génération leur aura donné en élargissant des mines d’énargie avec le plutonium et l’uranium restant et qui resteront accessibles.

L’autre voie c’est d’essayer de faire disparaître au maximum ces éléments à longue vie dont le premier, le plus abondant, est le plutonium. Il est dans les déchets nucléaires, dans le cas des combustibles non-retraités; il est aussi dans une plus faible partie dans nos déchets de retraitement. Cependant, si nous voulons épuiser l’avénir on doit préparer par les travaux que nous faisons maintenant pour le recyclage du plutonium et de certains transuraniens, cette période à laquelle nous devons faire face pour essayer de former textuellement le nucléaire de fission.

(I would like to thank Per-Eric Ahlström for his very objective and open presentation on the two options of the reprocessing and non-reprocessing of spent fuel. I would like to return to this aspect of recycling, since we are discussing reprocessing, but which we can present as recycling within an ethical framework for the management of wastes. Dr. McCombie and Mr. Bernero have spoken on this subject several times and it is, in my opinion, an essential point of ethics. It is true, as Charles McCombie said earlier, that the idea is not a new one. However, it seems to me that its application is increasing and at a level which directly concerns the public; I am speaking here of urban wastes.)
I am surprised that we find in France, a Latin country, glass recycling containers in every village. I know that in less Latin countries, one finds two, three, four such containers. My daughter is at present living in Germany and she is shocked by the number of garbage cans she must have and the sorting of the garbage this entails. I think waste recycling is an idea which responds to a deep public conviction that even if it is not possible to completely reduce the quantity of wastes, it is possible to do so on a selective basis. The idea that we are economising is likely a false one. Specialists, particularly those in the glass industry, have stated that recycling is more expensive than making new glass. It is the same for recycled paper. Thus, recycling must be understood in terms of ethical and not economical terms.

Nuclear energy cannot escape from this perceived need to recycle. In this sense, we must concern ourselves with the possibilities to recycle our nuclear wastes. I am not attempting to defend the French position, but I firmly believe it is our duty to study recycling. We must be honest and conclude, afterwards, what can reasonably be done and what is not possible. But for ethical reasons, we must look at all possibilities.

I would simply add that in studying the possibilities for recycling, we must also consider the end of the nuclear fission period. It seems to me there are two ways to do this. The first solution is not to reprocess and I would say that future generations belonging to countries who have not done any reprocessing will perhaps be happy of the advantage of our having left them so much potential energy given the plutonium and uranium which remain accessible.

The other path one can follow is to try to eliminate as much as possible long-lived substances; the first, and most abundant, being plutonium. Plutonium is present in nuclear wastes where the fuel has not been reprocessed; it is also present, in smaller concentrations, in wastes produced by reprocessing. However, if we want to work towards a safer future, we must by way of our present work on the recycling of plutonium and certain transuranics prepare for the period when we will have to try to stop in safe way all nuclear fission activities.)

Dr. Flowers

I might say that being from another country which carries out civil reprocessing, the United Kingdom, I am very conscious of the fact that it is not good enough to say that reprocessing and nuclear transmutation are ethical because they are a form of recycling. Recycling only becomes ethical, whether it be glass bottles or fuel elements, if the result of the recycling is of some benefit to society in reduced environmental impact or low economic costs. I understand the argument, but I do think we have to present it in terms of environmental impact and benefit rather than simply say it is recycling and therefore it is ethical.

Dr. Allan

I would like to add a comment on Per-Eric’s Ahsström’s presentation and reflect on Mr. Allocger’s intervention. It seems to me that what Per-Eric outlined, and what I had tried to outline earlier, is this concept of a strategy composed of a number of steps and which each include a variety of decisions that can be taken. There are two levels to the decisions that need to be taken. One is to know if deep geological disposal is the appropriate strategy. Within that strategy, if it is pursued, there are a series of decisions that have to be taken and which are displaced over time. In the Swedish case, the decision is that the next step to be taken is the selection of sites on which they will do surface characterisation. Once that has been completed a decision will have to be taken to actually do underground exploration because at that point you start to commit major resources. Following that, you have to make a decision whether to construct a repository followed by whether you are going to
put a small or large quantity of waste in that repository. Finally the decision is taken as to whether to continue or not.

At each of those decision points, you not only have to make a decision whether you want to take the next step, but you can review the strategy. Per-Eric has pointed this out very clearly; that sometime in the future, following a demonstration, society will be asked the question: "Do we continue with deep geological disposal? Do we continue putting waste in this repository?" This will be asked in the context of "do we have the right strategy?" That question will be answered by taking into account the wider range of issues and information developed in other programmes such as in partitioning and transmutation. What are the benefits of that technology? Today, because it is largely an R&D programme, we would not favour such a strategy on partitioning and transmutation, but thirty years from now it would perhaps be time to come back to that question.

I would also like to briefly comment on Dr. Ahearne's earlier intervention when he exposed the principle of environmental justice in relation to whether or not providing a benefit to a community which accepts a facility contravenes some other principle. I think this exposes a very interesting tension. On the one hand, and I agree with this, you have to take community's wishes into account and it is not appropriate or ethical to impose a facility on an unwilling community. On the other, we are hearing the view that even if a community is willing to accept a given risk because it has done some cost/benefit analysis and is prepared to accept the benefit, it is perhaps not ethical to permit that community to receive that facility. This is a good example of the tension between different ethical principles.

I thought there was a symmetry between that issue and the idea of cost/benefit analysis. To an individual, cost/benefit analysis is a practical means of coming to a decision, but it should not be used to balance the rights of future generations against our current obligations. This tension between environmental justice and the right of a community to decide its own future is similar to the issue of a community using the cost/benefit analysis to make a decision about what it would like to do today. There is also an obligation on society at large and on its various institutions, including waste management experts, to bring to the discussion the broader view. In the end what you find is a common ground between community interests, societal interests, and the obligations towards the future. It is on this base that one can make progress.

Dr. Ahearne

I would like to finally agree with Ron Flowers that it is quite important to make sure when we argue, for example, that recycling is good we be very careful to explain why that is so. There have been many different arguments in the United States as to why one should or should not reprocess. However, as Mr. Lefèvre indicated, we have found it is more expensive to use recycled paper than paper produced for the first-time. Many local communities are no longer accepting to recycle paper or glass because they cannot find a company willing to take that material. The market is simply not there.

We have gone through different cycles with reprocessing. Our administration has said you cannot reprocess because it is a proliferation hazard. President Ford was the first to make use of that argument, it was also President Carter's position, and, finally, it is the current administration's position. President Reagan and Bush were favourable to reprocessing, but nothing happened because when the economic side was looked at, it was concluded that reprocessing was more expensive. The utilities were not interested in funding reprocessing because it was a lot cheaper to get the fuel directly. One could argue that one might run out of uranium. That has not worked very well in the United States. We have uranium mines that are closed today because there is little demand. One might make the argument that it is better to dispose of the material after you have reprocessed it, but we have done studies indicating there is little difference in trying to dispose of the spent fuel directly.
We also have to be very careful of another problem the public has. If one argument is advanced for why something is going to be done and, when that argument no longer holds up, another argument is advanced, the public gradually begins to conclude it is not the arguments that are supporting it, but that there is some other motive. That just adds to public scepticism.

Dr. Bloser

I would like to make some comments on the very lucid observations of Mr. Ahlström. There are three different levels to address when discussing ethical questions and the implementation of a disposal programme. We have the technical level with the technicians, the political level with the politicians, and we have the public with the individuals. The questions we are discussing receive a different answer with respect to the different levels.

It is important for the implementation of the strategies to look at international standards. These play an important role in technicians being able to convince the public and politicians that things should be done in a particular way. We must be aware that most politicians are not conscious of the technical possibilities we have; whether it is better to reprocess or to have direct disposal. The situation in Germany is representative of our discussion. Some years ago in the United States, under the Carter administration, reprocessing was given up in favour of direct disposal. In Germany, during the 60s and the 70s, the reprocessing of nuclear fuels was the preferred option. After discussions about nuclear energy, politicians changed their opinion under public pressure. In our country it has been seen as a way to come to a consensus about the use of nuclear energy: to give up the reprocessing facilities as well as the idea of reprocessing. To be more precise, to introduce direct disposal as a second option. To help politicians make decisions requested by Per-Eric Ahlström, we must give them a base upon which they can rely.

In a world which is becoming smaller we need international standards. We must rely on international standards and international consensus. One example is the consensus reached at the international conference in Rio. If I consider the findings in Rio, in Chapter 22, there are many hints on how ethical thinking could be applied in practice. We find help in this document, elements of which will be developed in the Commission on Sustainable Development. If one looks at this year's second session, further advice concerning the use of nuclear energy in an environmentally-friendly manner can be found. Our task, after this workshop, should be to examine whether we are in conformity with the findings of these conferences.
Topic D
Retrivelability: A Spectrum of Views

Radioactive Waste Disposal: Taking Societal Views into Account

A. Rijp, Wim A. Smit and B.J. R. van der Meulen
Centre for Studies of Science Technology and Society
University of Twente
The Netherlands

Radioactive waste management and the safe disposal of nuclear waste are not purely scientific or technical problems. Because of different possible conceptualizations of risks, and the inevitable involvement of (ethical) values, radioactive waste management and the question of what are suitable criteria for the acceptability of these risks are societal problems. One immediate implication is that societal groups may have different views on the issue. How can a decision maker take various and often diverging views into account?

The Dutch government, in preparing its position on the question of using deep geological (rock salt) formations for the disposal of radioactive and toxic chemical waste, has organized a public consultation procedure on this issue. It has invited four organizations to give, in a (closed) seminar, their view on the matter. In addition a nation-wide open consultation was organized, inviting, via national and regional newspapers, people to give their arguments pro or contra.

The Centre for Studies of Science Technology and Society (University of Twente) was subsequently asked to analyze these views and arguments.

In this paper the methodological approach of argumentation patterns and argumentation scenarios, and the main results will be presented. It is important to emphasize that such an approach differs from usual policy analysis in that it does not identify and evaluate policy options, but elucidates the argumentative structures in the set of position statements and arguments. Thus, the analysis does not privilege one option or argument above another. Rather, it opens up options for political decision making.

1. Background

The aim of the two consultation procedures was to get a better picture of the arguments that played a role in the debate on disposal of highly toxic waste in deep underground. It should emphasized that the procedures were not intended to be a referendum, so there is no point in counting the numbers of proponents and opponents to certain arguments. Our evaluation of the outcomes of the consultation procedures is to analyze the structure of the argumentation, independent from the question how often particular arguments occur.

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In our analysis, and in the evaluation of argumentation, robustness is the key concept. In doing so, we depart from the usual approach (which is indeed applicable in a number of cases), where points of view and positions taken are assessed in terms of the correctness and relevance of the arguments on which the position is based. Whether a position is tenable then depends on the correctness of the arguments. If an argument turns out to be incorrect, another argument supporting the position must be given, or the position must be given up, or at least modified. In this type of discussion, the result will be an evaluation of arguments as correct or incorrect, and a distinction between tenable and untenable positions.

The discussion about acceptability of deep underground disposal of waste differs from such discussions on two points, and this has created problems in reaching acceptable conclusions. First, the participants in the discussion cannot agree on which arguments are correct, and which are not. The results of scientific research are not decisive, either, and become subject of discussion themselves. Second, the relevance of the various considerations cannot be ranked univocally: should retrievability be the dominant consideration, or safety, or the interests of future generations?

Even in cases where there is no consensus about correctness and relevance of arguments, discussion can be productive if it leads to articulation of the foci in debate. Foci in a discussion are the key points of departure and central considerations, of which the importance is recognized by all participants. A further result of discussion can be clarification: which arguments are widely accepted, and which are (hotly) debated; what are the links between certain arguments and certain positions.

There will still be no assurance of the correctness and relevance of arguments, but their robustness can now be assessed. Robustness is a pragmatic concept: arguments are robust if they can be supported without too much effort, through accepted principles, widely recognized policy, accepted results of research, agreed goals, or (other) robust arguments. Thus, an argument is robust if it can be defended when challenged. When such a defense is offered, it will lead to a further articulation of the argumentation. The process of discussion will not necessarily lead to consensus, but it will provide elaboration of argumentation which then allows assessment of further action, like the desirability of further research, the usefulness of further discussion, and/or the feasibility of reaching decisions. Robustness, thus, is characterized by (1) consolidation, at least a working agreement how to handle differences, and (2) articulation of the network of arguments, views, interests, etc. that lies behind the claim. The second characteristic is necessary, otherwise the claim would collapse at the first attack, or, like a fashion, survive only as long as the circumstances were favourable.

It is this conceptualization of the discussion that allows us to analyze and evaluate the arguments of the participants in the consultation procedures. Analysis and evaluation do not focus on the substance of the arguments as such, but on the coherence between the several arguments and with the subsequent positions.

The contributions of the participants in the seminar were well-articulated position statements, linked to a few key arguments. The contributions to the open consultation procedure varied from documents of several pages to postcards; from individual argumentation to preprinted sheets that had only to be signed; from positions supported by one argument (or none at all) to extensive argumentations, taking a multitude of points of departure, considerations, and arguments into account.

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2 The agreed upon summaries are available in Dutch.

3 77 separate arguments were distinguished, clustered under seven headings: future generations and retrievability (11), prevention and re-use (12), safety, isolation, management and control (30), environment (6), alternatives (7), international (6), political/administrative (5). [The list of arguments is available in Dutch.]
The significance of arguments, and their importance, appears only when their robustness is indicated (by the participant, and/or (especially in the case of submissions in the open consultation procedure) by the analyst) and when it is made clear how they lead to a conclusion that supports a position on deep underground disposal. One useful way to analyze robustness is to draw up argumentation scenarios: meaningfully linked arguments and points of departure which lead to a conclusion and a position. If this is possible, links among points of departure, among arguments, and between points of departure and arguments, are made explicit. If not possible, it becomes clear that such links are absent.

2. Patterns of argument and argumentation scenarios

Every public discussion or controversy has one or more foci: themes which are considered important by the majority of the participants (irrespective whether they agree or oppose), in the sense that the eventual decision should take these themes into account. A discussion can be mapped by tracing the foci and their evolution in the course of the controversy. The positions submitted in the two consultation procedures show that the discussion about acceptability of deep underground disposal of highly toxic waste is concentrated around six such foci, which are also recognizable in the list of 77 arguments, distilled out of the submissions in the open consultation procedure.

The six foci visible in the debate are:

1. Taking future generations into account,
2. Prevention and re-use or recycling (Integral chain management*),
3. Safe disposal according to ICM criteria (Isolation, Control, Monitoring),
4. Retrievability of the waste,
5. Saliency of the waste problem,
6. No export of waste.

We have phrased the foci as points of departure, rather than open questions, because the public discussion has accepted that taking future generations into account should play a role, that prevention and re-use or recycling is an aspect to be considered, etc. The discussion is on the how, and on the why behind that. And also, but often less explicitly, about the extent to which one point of departure can dominate another. The construction of argumentation scenarios is a way to make the latter explicit, as we will show below.

Although we can view each of the foci as a point of departure, their consensual/controversial status is different. The last two foci are barely contested. Almost all participants in the consultation procedures agree that waste should not be exported. This is in accord with international standards and agreements. So this can be taken as a shared point of departure. Whether there actually is a waste problem, is not doubted. Scenarios of future waste streams, as presented at the seminar, all conclude that the amount of highly toxic waste will increase. Thus, the recognition of the waste problem as a very real problem, and the requirement to solve the problem in your own country rather than to export it, are boundary conditions for any argumentation that wants to be robust.

The first three foci are closely linked to present environmental and waste policies, as presented in the National Environmental Policy Plan in which the concept of 'sustainable development' plays a

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* Integral chain management is the management of the whole product life cycle, with the goal of diminishing the burden on the environment.


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central role. Many participants in the consultation procedures indeed refer to sustainable development. In our analysis, we will not use the umbrella concept, but work with the several specifications that are offered.

Almost all position statements refer to one or more of these three foci. That it is necessary to take future generations into account, that prevention and re-use or recycling is desirable, and also disposal according to ICM criteria, is subscribed to by many participants, be it in varying ways, and not necessarily with the same conclusion.

The desirability of retrievability (focus 4) is controversial, and as will become clear later, is closely linked to assessments of safety of deep underground disposal, and of future possibilities to reprocess waste.

There are two reasons why the six foci of the discussion can lead to different patterns of argumentation and different eventual positions.

The first reason is that one of the points of departure is emphasized above another, and overrides the others in reaching the eventual position. For example, if retrievability is considered to be more important than safety, only those solutions qualify in which the safety target does not lead to disposal forms which make retrievability impossible. Or alternatively, if more weight is given to safety, the other points of departure will play their role but only in so far as they do not undermine the safety target.

The second reason is that the points of departure will be elaborated in different ways. This is particularly clear in the case of retrievability, where different criteria are used (partly in relation to judgements of desirability of retrievability). "To take future generations into account," while widely accepted as a general aim, is developed in different directions: for one participant, it means that waste must be removed definitively, for another that no waste may be produced that cannot be recycled, and for a third it implies retrievable storage of waste.

While it is possible to detail the variety of elaborations of the points of departure in scenarios, this becomes very complex. To map the present state of the debate and to assess robustness, it is sufficient to start from the different emphasis on the points of departure, and add detail only when necessary.

We shall construct four scenarios, three of them starting with one dominant point of departure and showing how the argumentation pattern branches out from it. The fourth scenario takes the list of foci and the need to take all of them into account as its starting point. The nature and linkages between the arguments are derived from the submissions in the consultation procedures. Thus, they reflect the present structure of the repertoire of argumentation, rather than any timeless ideal of correctness and logical coherence. This approach of mapping the debate also implies that in constructing different scenarios and patterns of argumentation, we are limited by the data. It turned out to be quite possible to take each of the first three points of departure, "taking future generations into account", "prevention and re-use or recycling" and 'safe disposal according to ICM criteria", as starting point for a scenario. It was not possible to create a robust argumentation pattern in which retrievability or definitive removal was taken as the dominant aim, and thus the starting point of an argumentation scenario. The fourth scenario, therefore, takes as its starting point the whole list of points of departure (in practice: the first four, because the other two function primarily as accepted boundary conditions), and asks which choices will have to be made.

The argumentation scenarios are composed from the arguments identified in the consultation procedures. They are structured as trees, starting with one or more central arguments, which branch out with the help of subsequent arguments. The arguments are presented in boxes with arrows
between them, indicating the flow of the argument toward a final position. Each scenario thus contains several argumentation patterns; adding up to a total of fourteen. These fourteen argumentation patterns map the debate, highlighting the skeletons of robust argumentation available at this stage of the debate. Here, we will just present the scenarios; in the next section, we shall give a brief evaluation.

The scenarios take the arguments submitted at the seminar, and the majority of the arguments that were identified in the public consultation, into account. The remainder (29 out of 77) do not really belong to forceful foci of the debate. They are rather diverse, and hardly articulated. They can be classified, as was done in the Dutch report, with the help of the labels 'environment', 'alternatives', 'international' and 'politics/administrative'. While these arguments are used in submissions, they often remain unsupported. This is the case for arguments under 'alternatives', like storage in nuclear power plants, or in the Sahara, and for an argument like 'the present Minister responsible for disposal of highly toxic waste is of party X, and the program of that party forbids deep underground disposal,' which we classified under 'politics/administrative.'

We emphasize again that our leaving arguments out of the argumentation scenarios does not imply a decision that they are incorrect or irrelevant. It reflects the fact that they are not part of the main lines of argumentation, are outside the forceful foci, and thus, have not been under pressure to have their support and linkages articulated. Because of this lack of articulation, they are not (yet) robust, and cannot be evaluated with the help of our method.
Argumentation scenario #1

[1] For the decision about deep underground disposal of waste, it is of great importance to take the interests of future generations into account. The present generation is responsible for the production of the waste, and has to make provisions so that man and environment will be protected, and remain protected, against the negative effects of this waste, also in the future. Because of the responsibility toward future generations, it would be better to produce no waste; thus, the emphasis in waste policy must be on efforts toward prevention and re-use or recycling. This implies that one must always choose for the least polluting forms and methods of production. Nevertheless, for the time being, waste generation cannot be completely prevented.

[1.1] Disposal of generated waste in the deep underground is not allowed because, the deep underground may represent a value in the future. The deep underground is the last environmental compartment which is not polluted. It is possible that future generations will want to use the deep underground for other purposes, so we should not trespass on it now.

[1.2] For some kinds of waste (like heavy metals) it is not desirable that they return in the cycle. Since such substances remain poisonous, they must be isolated from the biosphere. It is irresponsible to force future generations to take care of this waste. Thus, the definitive disposal of this waste must be realized now. Because of natural isolation, the deep underground is the safest solution, and active management is not necessary.

[1.3] To reduce the negative effects of dangerous waste as much as possible, the aim must be to render it harmless at some moment. Thus, the waste must be stored retrievably. Different kinds of waste must therefore be stored separately.

[1.3.1] The deep underground is not suitable for such a type of storage.

[1.3.2] The deep underground is suitable for such a type of storage.

[1.4] The waste that is generated must be stored as safely as possible. The deep underground is not suitable, because there are too many uncertainties about long-term behaviour of the deep underground, the influence of the waste on the deep underground, and about the possibility to manage storage in the deep underground over long periods. To intervene when calamities occur is difficult with disposal in the deep underground, perhaps impossible. The risk is thus that future generations will, at some stage, be confronted with the dangers of the waste.
Argumentation scenario #2

[2]
The most constructive solution of the waste problem is to not generate waste anymore. Thus, prevention and re-use or recycling of (highly toxic) waste must be emphasized. The means to do so are available. Where possible, a clean (or cleaner) technology must replace the old way of production. Producers of waste must be taxed more heavily. One can avoid generating electricity through nuclear power, and thus avoid the production of large amounts of nuclear waste. The waste that cannot be prevented, re-used or recycled must be made harmless, or stored retrievably, so that future generations can re-use or recycle the waste.

[2.1]
Disposal of the waste in the deep underground is not a good solution. The safety of the storage cannot be guaranteed. There are too many uncertainties about the long-term behaviour of the deep underground, the influence of the waste on the deep underground, and about the possibility to manage storage in the deep underground over long periods. To intervene when calamities occur is difficult with disposal in the deep underground, perhaps impossible. The risk is thus that future generations will, at some stage, be confronted with the dangers of the waste. Waste disposal in the deep underground therefore does not meet the ICM criteria. Waste disposal in the deep underground also implies that the waste is not retrievable. When in some future time methods to that extent are developed, the waste cannot anymore made or harmless or be re-used.

[2.2]
Waste disposal in the deep underground is the least bad way of waste removal following ICM criteria. With our present technological knowledge, and because of natural isolation, it is possible to store the waste in the deep underground sufficiently safely. Waste disposal in the deep underground is less sensitive to environmental terrorism, war, crashing airplanes etc., because of its natural isolation. Active management (control and monitoring) is thus hardly necessary. The disposal can also be done retrievably, so that one of the most important objections against disposal in the deep underground is removed.

[2.3]
Disposal of highly toxic waste in the deep underground takes the interests of future generations insufficiently into account, and entails high costs. In the sense that high costs are an incentive to search for alternatives, disposal of waste in the deep underground is acceptable as a stimulus for prevention and re-use or recycling.

[2.4]
With disposal of highly toxic waste in the deep underground, a (cheaper) solution to the waste problem is available, while the waste will become invisible and irretrievable. This reduces the incentives for prevention and re-use or recycling.

[2.4.1]
Disposal in the deep underground must therefore be rejected.

[2.4.2]
It is only present highly toxic waste that may be disposed in the deep underground. After that, one can start with a clean slate.
[3] A basic principle of present environmental policy is to make sure that man and environment do not experience harmful effects of non-processable waste. Thus, the waste must be stored effectively isolated from the biosphere, and the storage site must be controlled and monitored well. In this respect, we must learn a lesson from dumping in the sea. It would be better to prevent generation of waste, but that is not always possible. Neither are, in most cases, new ways to process waste to be expected in the short term. Therefore, one should choose the safest method of storage.

[3.1] The waste in question remains harmful for a long time (thousands of years). Thus, solutions for a few decades are at best partial. Since it has been proven that the deep underground can isolate harmful substances from the biosphere for long periods, it is sound to move toward disposal in the deep underground. An additional argument is that the soil suffers much more erosion than the deep underground. The safety of the deep underground has been confirmed by the OPLA report.

[3.2] For waste disposal, the Netherlands follows the ICM criteria. Effective control and monitoring are then essential: they are necessary to be able to intervene when the isolation should fail, and reduce the harmful effects to a minimum. In addition, active management links up with the aim to process the waste eventually. For disposal in the deep underground, effective monitoring and control is not possible. But these are necessary, because of the many uncertainties about the behaviour of the deep underground. So it is better to store waste above ground.

[3.3] Disposal of waste has to meet the ICM criteria. Also in the case of disposal in the deep underground, active management is possible. But it is then necessary to store the waste retrievably. Such a reversible storage method in the deep underground is to be preferred to storage above ground, on the basis of safety considerations.
The problem of non-processable waste is a serious problem, and a structural solution is demanded. It would be better for the environment if the waste were not generated; production of waste must thus remain at a low level. In the short term, however, it is not an unsolvable problem if sizeable amounts of radio-active and chemical waste continue to be generated. These wastes have to be stored, well isolated from the living environment. No method to achieve this should be rejected a priori. Space is available in the deep underground, and one should not reject in advance the option to use this space. Selection of method must occur on the basis of safety, the interests of future generations, ICM criteria, possibility of retrieval, etc.

From an environmental point of view, it is desirable that the waste will be made harmless at some moment of time. Therefore, the waste should be stored so as to be retrievable. At this moment, there are many uncertainties about the behaviour of the waste in the deep underground. Research must be done to find out if retrievable storage in the deep underground is indeed possible in a safe and economically acceptable way. As long as this has not been clarified, the waste must be stored above ground.

The deep underground guarantees good isolation of the waste (see OPLA report). In addition, the waste is retrievable for 50 to 100 years, so that possible more sustainable solutions can be taken up. If by then no method of processing the waste has been found, it is sensible to move to definitive disposal. The deep underground can therefore be used for storage of waste.

Storage in the deep underground is not consistent with the interests of future generations, does not meet the ICM criteria, cannot be guaranteed to be safe, and is not retrievable. So it must be rejected.
Analysis of the argumentation scenarios

The scenarios, and the argumentation patterns contained in them, show how arguments are linked up and lead to an eventual position. This reconstruction does not lead to a conclusion, one way or the other, whether disposal in the deep underground is the right thing to do. But that was not what we set out to do. The aim was to bring out the actual and potential linkages between the arguments identified in the consultation procedures.

Some links turn out to be more easy to make than others. If taking future generations into account (focus 1) is foregrounded, it is almost self-evident (for the participants) to find prevention and re-use or recycling (focus 3) important. While there are different assessments of how far disposal in the deep underground meets ICM criteria, the importance of safety, articulated in terms of the ICM criteria, is a returning element in the scenario’s. So safety, and the ICM criteria, are obligatory stepping stones in the argumentative patterns. The difference in eventual positions derives from the different detailed assessments.

Using the metaphor of a landscape, with its hills and valleys, and gradients of inclination and effort to traverse in general, one could speak of the landscape of the argumentative repertoire in the debate on waste disposal in the deep underground. The analyst maps the terrain, by finding out which have become the preferred pathways of the participants in the debate. But it is the shape of the landscape rather than an opinion poll, which is what interests him, and the policy maker.

The four argumentation scenarios are exercises on paper, and can be seen as geodetic experiments: which combinations of arguments can be constructed, and which patterns become visible, which tell us something about the lay of the land (that is, the present "landscape" of the state of the debate, not some unchanging bedrock of correct argumentation that we have to aim for). Other scenarios could be constructed, but we would claim that the patterns -- the linkages between arguments that cannot be undermined, or only with great effort, as well as the junctions, where paths diverge -- will remain the same.

While the different detailed assessments lead to different positions on waste disposal in the deep underground, one should not let oneself be blinded by the differences in outcomes. The debate has progressed sufficiently for the argumentative landscape to stabilize: participants as well as analysts recognize the peaks and the valleys, and while diverging on the route to take through the landscape, share a recognition of what the important issues are.

It is now possible to make a second step. First, we identified arguments in the consultation procedures, and combined them in a limited number of argumentation scenarios. This enabled us to distinguish between arguments relevant for the main lines of the debate (shared roads as well as separate routes, due to fractures in the landscape), and those less relevant at this stage of the debate (independent of the question whether they are correct or not). The second step is to identify robust patterns, and loci of divergence in assessments.

One recurrent and robust pattern (see especially scenarios 1 and 2) is how taking future generations into account (focus 1) is coupled with prevention and re-use or recycling (focus 3), and how this then, via the argument that the waste problem remains (in spite of the efforts at re-use or recycling and prevention), leads to a search for solutions that meet the ICM criteria (focus 2). It is only in scenario 2 that retrievability gets greater weight, in the sense that it comes up earlier in the argumentation chain, and helps to determine the nature of the solutions. The reasoning is understandable: when prevention and re-use or recycling are taken as the point of departure, retrievability is a positive factor, because it implies that future possibilities of processing and re-use or recycling can be exploited.

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A second recurrent pattern is the divergent assessment of the safety of waste disposal in the deep underground, which is always coupled to arguments about the possibility and desirability of storing waste retrievably. While in the first recurrent pattern the desirability of retrievability was coupled to future possibilities of reprocessing, here it is coupled to an assessment of insufficient safety of disposal in the deep underground. This pattern is fully explicit in scenario 3, and appears in scenarios 1 and 2 in the arguments subsequent to the points of departure 'taking future generations into account' and 'prevention and re-use or recycling'.

Note that we do not discuss the substance of the issue whether disposal in the deep underground meets the ICM criteria. What we highlight is how the diverging assessments form a recurrent pattern, and how this couples, in specific ways, to the theme of retrievability (focus 4). When two problems with divergent assessments interact, there might well be a "wicked" problem. Rather than trying to solve it, we map its features in the argumentative landscape. Participants in the debate, including policy makers, can see their surroundings more clearly now, and plan their route accordingly.

There is a third recurrent pattern: the way that the uncertainty about long-term circumstances of waste disposal in the deep underground surfaces in argumentation patterns. In pattern 1.4 it occurs, and this in relation to focus 1, but it returns in patterns 2.1 and 4.1. If one is risk averse, uncertainties are an argument against (in this case) disposal in the deep underground. Some postpone a decision and ask for more research, others doubt if research will be ever able to provide conclusive insights on this point.

In addition to the recognition of recurrent patterns, a conclusion is possible about the ordering of the focal themes. Rephrasing our description of the recurrent patterns, we can say that there is a *de facto* argumentative hierarchy:

- Firstly, that there is waste, and that there will be waste, about which the Netherlands should do something, is recognized by everybody (saliency, focus 5).

- Secondly, that one should take future generations into account is a point of departure that nobody opposes, and similarly for prevention and re-use or recycling, which is linked to the future generations theme.

- Thirdly, safety, and its operationalization in ICM criteria, is accepted as a relevant point of departure by everybody.

- Fourthly, at this level, differences emerge that are practically irreducible, at least for the moment. Can disposal in the deep underground meet the ICM criteria?

- Fifthly, an additional argument about uncertainties (about long-term circumstances of deep underground disposal) shows up difference in attitudes toward risk taking: in a risk-averse attitude, uncertainty is a sufficient argument to reject deep underground disposal, while risk-management attitudes look for solutions, like retrievability, which allow handling of the risk when it materializes.

What is a low-level and, in a sense, technical problem: how to meet ICM criteria, becomes an issue of public debate because of uncertainties and the various attitudes to face uncertainty. Because of this, the issue of retrievability becomes salient, and a focus of the debate which could turn over the present hierarchy. For the moment, it is primarily an open and contested issue: what is retrievability? Which disposal routes are retrievable? Is retrievability at all possible with deep underground disposal? As long as the contest is carried on within the present argumentative hierarchy, in which the higher levels have become stabilized (at least in the Netherlands), one can try to address the issue as a
technical problem, where research and other ways of articulation of the issue will contribute to progress.

Our exercise with argumentation scenarios, however, shows that the different assessments of safety, which are foregrounded in scenario 3, are irreducible. If other points of departure are used to construct a scenario (as in 1 and 2), the difference in assessment occurs. What the other points of departure do is to introduce additional arguments, which modify the choice for or against disposal in the deep underground. Thus, the assessment of safety will become further articulated (and more complex). One has to actually go through this process of articulation to find out whether it can resolve the issue of safety or not. So the irreducibility is not a logical point, but what one could call a historical point.

The reason why we reconstructed the argumentative landscape of the debate was to clarify the policy choice for or against deep underground disposal. What has become clear is that there is no logically robust position. Societal robustness, however, which may be even more important for policy, is present, at least to some extent. The importance of future generations, and prevention and re-use or recycling, are stabilized parts of the landscape. After that, the only robust part is the recognition that there is uncertainty. Implicit in our analysis is the point that research per se will not resolve such uncertainties; only when it is part of an ongoing articulation process. So it is important to continue, and improve, such articulation processes. Reconstructing argumentative landscapes, and offering the mapping to participants in the debate, is one contribution to such an articulation process. This is what we have done in this report.

If a policy decision has to be made now, policy makers have to anticipate on the outcome of such articulation processes, as well as to elaborate their own way of decision making under uncertainty. Anticipations can be improved through research, especially research in the dynamics of public controversies. Decision making under uncertainty also depends on attitudes of risk aversion or risk embracing.

Reconstructing the argumentative landscape, as we have done, does not have a direct or linear impact on policy making. Rather it opens up spaces for policy action, or in other words, releases the initiative to the polity. Our identification of the importance of 'retrievability' as a contested issue does not foreclose any policy options. Indeed, the importance of the issue is known already. What we have done is to show how it is located in the argumentative hierarchy; or in terms of our metaphor: where the crossing of roads is located in the landscape. Thus, the issue can be put on the policy agenda in a more structured way, and treated accordingly.
Appendix on Method

Used in "Radioactive Waste Disposal: Taking Societal Views into Account"

Analyzing the heterogeneous material produced in consultation procedures cannot be done with traditional approaches of policy analysis, which are oriented to the analysis of a problem, or the analysis of one or a few (policy) documents. Here, there are views and arguments of varying nature and status, and their force derives also from the fact that they have been submitted in a consultation procedure.

By viewing the material as a product, and thus an indication, of the repertoire of views and arguments that characterizes the controversy at this stage, other methods of analysis can be mobilized, and we will set them out briefly in this appendix.

We would argue, in addition, that the notion of 'repertoire' is important to understand the dynamics of controversies, and offers new possibilities for policy making. Traditionally, controversies like the one about burial of waste in the deep underground have been seen as reflecting a problem that has not been solved, and policy makers should work towards actually getting this problem solved. Over the last decades, when it became clear that technical problem solutions did not make the controversy go away (partly because different participants see different problems), the policy makers saw their task as one of conflict resolution, or at least conflict management. While important, the substance of the controversy may be lost out of sight in the eagerness to restore the peace. Studies of the dynamics of controversies have shown that there is a third aspect: the improvement of argument, the articulation of views, the learning which positions can and which cannot be maintained, the increase in robustness of certain other positions, and thus a partial closure. We have called such developments 'repertoire learning', because it is not individual learning, but an improvement of the repertoire relevant to the issue and the arena. The controversy, or rather, controversies, about smoking and health provide striking examples (See Rip 1986b).

When policy makers recognize the possibility of this dynamic, they can work towards (further) repertoire learning, and design their measures to suit this purpose. The mapping of the repertoire then becomes an important first step. The methods to do so are then not just a way to handle the heterogeneous material that is produced by a consultation procedure; they are policy-relevant in their own right, and the analysis can lead to policy advice. After setting out the methods, we will briefly come back to this point.

Mapping the repertoire

The notion of 'repertoire' has been used to describe and analyze the content of a culture or a subculture, say of a community, or an occupational group, or an organisation. The repertoire of stories, metaphors and images of an organisation has become recognized as an important factor in shaping atmosphere, work, success, and is now treated as an opportunity to develop management tools.

Repertoires emerge in mutual dependency situations with some shared activities and a certain boundary towards the "outside." Seen in this general way, it can be applied to controversies as well: there is a limited set of issues and participants linked to each other, an (evolving) arena as it were with an (evolving) agenda. One can trace the repertoire by identifying the arena and reconstructing the repertoire of its participants; and/or by identifying the agenda, and reconstructing the repertoire through analysis of documents and other contributions to the agenda.
In the case of the consultation procedures in the Netherlands, a mixed approach was used. For the seminar, key participants were invited to document and discuss their arguments, and this provided us with the data to map the repertoire. For the public hearing, no bounds were set on participants, but the submissions had to relate to the issue. This entrance point into the repertoire allows a broader scope, but may also include noise. One way to distinguish signals from noise, without biasing the analysis by throwing out arguments or views because one thinks they are irrelevant or plain silly, is to have a closer look at their authors. While we did check the source of the submissions, we did not choose to delete possible outliers. The check was important to interpret certain features, like the frequent recurrence of a few standardized arguments. Standardized responses had been printed, and people needed only to sign the sheet and send it off to have a submission.

At a later stage in the analysis, there was a possibility to distinguish relevant from not-relevant at-this-moment by finding out what could be included in argumentation scenarios, and what was not worthwhile to try to include. We listed the arguments that were not included separately, and discussed our reasons. So others could, if they so wished, create different scenarios with different inclusions. Our contention is, however, that we have mapped the central part of the repertoire as it characterizes the state of the controversy.

**Argumentative patterns**

In our analysis, we were not interested in all elements of the cultural repertoire of the controversy. For example, we did not consider the style of discussing and the way conflicts tend to be resolved (which is different in different countries), although these are interesting features, and are important to estimate the feasibility of conflict resolution measures.

Our interest was in the arguments and reasoned positions, and in the argumentative patterns that might be important. In the main text, we have used the metaphor of argumentative landscape to refer to this aspect of the repertoire. A landscape is shared by the participants, you can move about it, in it, and take different paths. Some paths are easier than others, and the landscape can be moulded, intentionally and unintentionally, and such changes shift the gradients. One should not take metaphors too far, but one can see how putting a lot of work in finding ways to contain toxic waste, and being somewhat successful, is shifting the gradients of argumentation about deep burial in the same way as flattening a hill and building a new road does. The argument about retrievable storage for 50 years and then see how much technical progress we have made, is like keeping the hill as it is (or the town with its narrow and winding streets) and building a bypass.

If this metaphor adequately captures what the argumentative repertoire in a controversy is, the next step is to isolate the building blocks (arguments and positions) and their linkages. If one has one document only to analyze, a variety of methods is available.

One cluster of methods derives from Stephen Toulmin's seminal work on argumentation, and uses his structuring of practical reasoning: data are provided for a claim, there is a warrant to go from data to claim, and there is backing to support the warrant (or the conditions under which the warrant is valid). In practice, argumentation is elliptic, and the analyst has to complete it in order to make the structure, or better, the possible structure, visible. Schellens, who has analyzed a discussion in the Dutch newspapers, 1981-1982, on burial of radio-active waste in salt formations, notes that the Toulminian scheme captures certain types of argumentation very well, but others, like reasonably invoking authority, or reasoning by example or by analogy, much less. His analysis is oriented to the characterization and evaluation of the arguments of the several participants in the debate, not to a characterization of the repertoire.
A second cluster of methods derives from the new rhetorics of Perelman and Olbrechts-Tyteca, where effective argumentation is foregrounded rather than reasonable argumentation (there is a lot of overlap, though; the difference is primarily in the orientation from which the arguments are evaluated). The new rhetorics have broadened out and become fashionable (cf. also Enos and Brown 1993). For our purpose, the methods are important, not the substantial discussions, e.g. about the rhetorics in scientific discourse. Rhetorical analysis, as we see it, is the analysis of how force is exerted in and through text and speech, with particular emphasis on how forceful associations are put up. The Toulminian scheme then is one, and recurrent, form of forceful association, and one where the force derives from the structure of the argument, rather than the content of the data or the backing. But there are other schemes, for example where strategic assessments and inference carry the force. How actors position themselves in a debate or controversy allows inferences as to the strength of argumentative linkages. For example, while the tobacco companies had been fighting the link between smoking and health (particularly, cancer) with data, arguments, and other weapons, at some time during the 1970s, they realized that they were not reaching their audience anymore with this kind of argument, and stopped with their emphatic criticism of the smoking-cancer link. In the public debate, this then led to a new kind of argument: 'If even the tobacco companies do not criticize the smoking-cancer link, it must be true.' This was an irreversible shift in the dynamics of that controversy. (See Rip 1986b for more details.)

A third cluster of methods is of more recent origin, and derives from literature, text analysis and culture studies. It is variously called discourse analysis, narrative analysis or cultural analysis. The force of an argument is seen to derive from the cultural schemata into which it fits, or from the story and its emplotment, or from socio-cultural definitions of what is natural and obvious. An example is the way 'the endless frontier' schema allowed Kennedy's argument for putting a man on the moon before 1970, to be more convincing than it would have been otherwise. At the level of analysis, one can trace such forces sometimes by looking at the modalities and the sequencing devices in the text. Compare for example the effect of "Until now, gas separation with the help of membrane filtration is not yet applied in our country," with the effect of "Gas separation with the help of membrane filtration is not applied in our country." The data are the same, but the framing is different, and the implicit scenario of the first phrase ("but it will, or should, be applied") derives its force from a cultural schema of 'inevitable progress'. (The example is drawn from a detailed analysis in Van Lente 1993.)

For our purposes, the isolation of the main building blocks is important, not the detailed analysis of concrete argumentative patterns. Because the data are drawn from explicit submissions, they are already shaped so as to bring the arguments and their linkages out. When necessary, we fell back on our argumentative intuition, as supported by our experience with rhetorical analysis, discourse analysis and narrative analysis to make sensible choices; for example by looking at the sequencing or the modality.

The modality with which an argument or a claim is expressed is particularly important to find out what is generally accepted. Or, more generally, what is sufficiently robust to withstand critical deconstruction. For scientific articles, such modalities have been traced as evolving from: 'We speculate that ...' or 'X might be caused by ...' or 'Some authors have suggested that ...' for the uncertain; via 'It is probable ...' or 'X appears to be caused by ...' or 'Smith and Jones have noted that' for the plausible but still not robust; to 'It is certain that...' or 'As it is well-known that X causes ...' or '... (i.e. the claim is made without there being any need to refer to sources). In other writing, similar gradings of certainty, acceptance and robustness can be distinguished. In our data, qualifiers like 'naturally' or 'it is obvious that' can be used as indicators of robustness, or, tactics to try and claim robustness for one's less certain or less accepted point.

Once building blocks have been isolated, one can trace their modalities across the whole set of data. Not just as arguments for a particular position, but also in the way the arguments for another position are referred to. If these are addressed, and in a way that it is clear that the author feels s/he
is forced to address them (because of the state of the controversy), then we have found a focus of the present state of the controversy. The modalities of presentation then allow us to decide whether this focus has been articulated and accepted, so as to become available as a boundary condition to all argumentative patterns, or a point of departure that has to be used, as a starting point or later on in the argument, or whether it is a "wicked" focus which is full of uncertainty and divergence, at least at this stage. Note that we are not interested in everything that is uncertain, but in those problematic issues that have to be addressed, because they are a focus of the controversy.

Up to this point, the analysis maps the state of the repertoire in the same way as a sociologist would do, using certain methods to find out what is the case, even if these are never fully objective, because they require judgements of the analyst in a number of places. In our analysis, we have gone one step further in order to evaluate the argumentative repertoire. We wanted to find out what the structures of the main argumentative patterns were, and whether the "wickedness" of one or more foci was related to a problem in the argumentation, or not (and if not, it might have a variety of causes, including unconstrained interest politics).

So we went back to argumentation analysis, and the basic Toulminian scheme, and used it as a shell to build a number of argumentation scenarios, using only the main building blocks, and leaving out most of the data and backing, only referring to their presence or absence. A path through such an argumentation scenario will specify an argumentation pattern, and one that qualifies as argumentatively sound, because the steps necessary for sound argument are taken.

The argumentation patterns we created in this way need not coincide with any concrete argumentation found in our data, or elsewhere. They highlight what the argumentative repertoire has to offer at this stage. And they have a diagnostic aspect as well: not only do we work with what is available (so the limitations of our scenarios and patterns are limitations of the repertoire), we also try to fit the "wicked" foci into the scenarios, and see what happens. One conclusion which we drew in the main text was that the "wicked" focus of retrievability ("wicked" in the sociological sense, in that participants disagree how to handle the issue) plays indeed a wicked role in the argument: it cannot be used as the starting point of a scenario of its own, and when it appears in another scenario, it creates forks in the sequence. This is not to say, we hasten to add, that the issue of retrievability cannot be resolved. It is a diagnosis of the present state of the repertoire.

**Repertoire learning and the Introduction of forceful foci**

The repertoire in a controversy evolves, and when the repertoire at some later stage is better (in terms that must be specified), repertoire learning has occurred. No particular individual need to have learned; the change could have happened through new participants. As we noted in the introduction: some arguments cannot be maintained anymore, others become easy to mobilize. If a participant tries to press one of the untenable arguments, the reactions will be such that he will quickly learn that he should not (unless he can come up with a new defense, of course). In terms of our metaphor: the argumentative landscape has changed, and the movements through it experience a different gradient. Even if you do not know the new lay of the land, you will quickly learn the difference between an easy slope and a steep hill.

Repertoire learning has been described by Whiteman (1982; 1985), though without using the concept, for the utilisation of OTA reports by the American Congress. He identifies substantive, elaborative and strategic use, and describes outcomes, including repertoire learning: "There were some arguments that people were making that were just dropped because they didn't make sense anymore in the light of the OTA report." (Whiteman 1985, at p. 221). He then goes on to note that strategic use of analytic information (which some might decry as improper) actually increases the sophistication and may shift the focus of Congressional debate, exactly because strategic use occurs in situations where
interests are at stake, and proponents and opponents have to be careful about the quality of their weapons, including the analysis and arguments they use. We add that it is not a coincidence that strategic use is more frequent when the topic is controversial. The further implication is that attempts to reduce strategic use might actually diminish the amount of learning that occurs on the basis of an OTA report.

Repertoire learning does not occur automatically, just as new knowledge or new analysis will not be utilized already because it happens to be there. There must be an incentive, and controversy is one incentive. When the socio-cognitive dynamics of controversies are traced (see for such an analysis, and references to relevant literature, Rip 1986b), two features stand out.

One is that forceful foci are necessary for further articulation and possible agreement or accommodation; otherwise, too little is at stake, and parties prefer to go their separate ways. Intended government regulation or policy making can be such a forceful focus; a credibility problem (say, for chemical industry and environmental impact of its processes and products) can be another.

The second feature is that the actual nature and sequence of the forceful foci determines the content of the eventual resolution, including the content of the repertoire then achieved. Those issues will have become articulated and will have led to robust insights that were at stake at some earlier stage. In the 1970s controversy over recombinant DNA research in laboratories, the risk of escaping micro-organisms quickly became a focus, and when it turned out that these could be contained (through the use of 'crippled' micro-organisms and through bureaucratic classification of extent of risk and nature of precautions), and there was no other forceful focus, the controversy closed and the implicated repertoire was consolidated. "The risk of r-DNA research appears to be considerably less than initially believed," (true) became: "The risk of r-DNA research is negligible." Insofar as there still was debate, it centred on the actual use of r-DNA technology in production processes and products, but there different issues were at stake.

The implications of this brief excursion to the socio-cognitive dynamics of controversies are that repertoire learning occurs better when there is something at stake, and that this can be understood because it is in and around a forceful focus that articulation occurs. Consolidation, the second feature of robustness, may be, but need not be, the end result of such a dynamic. It is difficult to decide whether consolidation has occurred prematurely, and should be broken up -- even apart from the question whether some participant might actually be able to break up a consolidated position.

A policy implication is that when lack of articulation and consolidation is diagnosed, the policy maker should stimulate repertoire learning, and the best instrument to do so is to create a forceful focus. In our case, this would be to decide about a policy that addresses retrievability, the "wicked" focus. Not because the policy maker has found the right answer, or has resolved the conflict between the parties, but because he sets learning in motion. Thus, it is not decisive which way the policy takes up the retrievability issue, as long as it does take it up. The learning that occurs then may lead the policy maker to revise his original choices, but that should not be a problem.
Bibliography


Geological Disposal of Long-lived Radioactive Waste and "Sustainable Development"

Mandred Bloser
Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit

Helmut Röthemeyer
Bundesamt für Strahlenschutz

Germany

1. Introduction

On the basis of the results of the "United Nations Conference on Environment and Development" (UNCED) in Rio de Janeiro 1992 which elaborated a concept of "sustainable development" in its Agendas 21, some countries have drawn conclusions on design features of repositories for the final disposal of toxic wastes. This paper explains why retrievability and reversibility are not favourable design features for the geological disposal of radioactive waste within the concept of "sustainable development".

2. What Sustainable Development Means?

"Sustainable development" means satisfying the needs of the present without compromising the ability of future generations to meet their own needs by:

- sustained, long lasting technical development;
- fulfilling human and environmental protection goals now and in the future;
- saving resources and conserving the environment for future generations;
- placing no undue burdens on future generations without denying their right for intervention at a later date.

3. What Geological Disposal Means?

Geological disposal of long-lived and/or high-level radioactive waste aims at achieving long-term isolation from humans and the environment with reasonable assurance by means of:

- emplacement in a stable geological formation several hundred metres below the surface;
- implementation of the multibarrier concept; this includes backfilling and sealing of all openings;
• avoiding maintenance work and surveillance after sealing as a necessary safety feature.

The basis radiological requirements for the protection of humans and the environment arise directly from radiation protection principles.

The arguments for or against retrievability and even reversibility are based on value judgements of a technical and ethical nature. While these judgements usually result in repository designs without the option to retrieve the waste, the supporters of retrievability or reversibility base their arguments on:

• a lack of the necessary knowledge to ensure safety;

• the conservation of resources;

• a possible optimization on the disposal technology in the future.

Those arguments are dealt with under Item 4 as follows.

4. Arguments and Answers

4.1 Necessary knowledge

Prior to designing and construction of a repository for long-lived radioactive waste necessary knowledge for a sustainable, long-lasting development and safe use of the repository is received by careful and thorough reconnaissance by geoscientific and mining procedures supported by the appropriate use of safety assessment methods. Unavoidable uncertainties and lack of detailed knowledge can be compensated by conservative and pessimistic assumptions, uncertainty analyses and observations from natural systems. Waste that have thus been disposed of in a geological repository are much less accessible than stored waste designed for retrievability/reversibility; it is therefore better protected against both human activities and natural processes. Thus reasonable assurance can be gained that a safe design and construction of a geological repository will keep its safety features far into the future. Safety of people and protection of the environment can be sustainably maintained without human intervention.

4.2 Conservation of resources

High-level waste may in the future be a potential resource for useful material. Then it can be used within an integrated life cycle management; i.e., recycling prior to conditioning should be pursued, e.g., in a reprocessing plant rather than to retrieve the waste from a repository and chemical treatment of the retrieved waste. For the time being a demand for recycling the waste, e.g., from operation of nuclear power plants is not in sight, let alone the re-use of nuclear waste in repositories.

A sealed repository without the designed option to retrieve the waste, however, may also be exploited as a "deposit", if this meets the needs of future generations.
4.3 Optimization of disposal technology

Research and development work concerning the waste form and disposal method may provide better options in the future than those existing today. As safety goals have to be met anyway, options are not necessary in principle. Nevertheless, options, e.g., the separation and partitioning of long-lived radionuclides, may be developed to minimize the residual risks.

The goal for possible future risk - minimization must be weighed up against a definite risk increase and a higher burden on future generations by postponing a decision needed today. When, e.g., partitioning and transmutation are viable ways to get rid of long-lived radionuclides, this technology could be used for the waste then produced and not for the waste already emplaced in a repository.

Permanent retrievability of emplaced radioactive waste require accessibility. Accessibility increases the risk of a geological repository (geotechnical stability, exposures to the personnel, the general public and the environment) and is in contradiction with the minimization of radiation exposure. The minimization principle is met only after the backfilling and sealing of all access shafts, tunnels and other openings are completed. Hence, retrievability and reversibility as a design feature violate this proved principle.

5. Final Disposal, International Consensus Documents and Sustainable Development

5.1 In Chapter 22 "Safe and environmentally sound management of radioactive wastes", the (Report of UNCED in Rio de Janeiro stresses, that states, in cooperation with international organizations, where appropriate, should

- provide for their processing, conditioning, transportation and disposal [22.4 (a)];

- support efforts within IAEA to develop and promulgate waste safety standards or guidelines and codes of practice as an internationally accepted basis for the safe and environmentally sound management and disposal of radioactive waste [22.4 (b)];

- promote research and development of methods for the safe and environmentally sound treatment, processing and disposal, including deep geological disposal, of high-level radioactive waste [22.8 (a)].

The UN Commission on Sustainable Development (CSD) stated in its report on the 2nd session in May 1994 and in a resolution, that "efforts had been geared towards identifying and establishing permanent disposal sites for radioactive wastes". The CSD expressed its support for the work of the IAEA and the international cooperation within the framework of the RADWASS Programme. Apart from that, the CSD urged governments to apply preparatory measures for final disposal. That means, that the CSD relies on the work of the IAEA particularly.

5.2 The international scientific discussion led to the conclusion, that geological disposal can be performed in a safe manner (cf. International NEA/IAEA/CEC Collective Opinion, OECD/NEA 1991). The respective activities are supported by the existing and the forthcoming international consensus safety objectives and standards. These
objectives and standards do not rely on retrievability and/or reversibility. Neither does the Collective Opinion. The forthcoming new safety fundamentals of the IAEA "The Principles of Radioactive Waste Management" and the IAEA "Radioactive Waste Management Glossary" define disposal as "the emplacement of waste in an approved, specified facility (e.g., near surface or geological repository) without the intention of retrieval". The existing IAEA Safety Standard No. 99 "Safety Principles and Technical Criteria for the Underground Disposal of High-level Radioactive Waste" (published in 1989) sets out "the basic design objectives for underground high-level radioactive waste repositories, such that humans and the human environment will be protected after the closure of the repository and for the long time periods for which the waste remain hazardous; it establishes principles for the protection of future generations and quantifies the level to which they should be protected. Finally, it provides guidance on the technical aspect of repository design such that the principles may be complied with".

With respect to the protection of future generations it states in Principles Nos. 1 & 2:

"The burden on future generations shall be minimized by safely disposing of high-level radioactive waste at an appropriate time, technical, social and economic factors being taken into account". "The safety of a high-level waste repository in the post-sealing period shall not rely on active monitoring, surveillance or other institutional controls or remedial actions after the time when the control of the repository is relinquished". This means that present generations should not rely on the means, ability and stable societal conditions of future generations to manage waste presently produced.

The Safety Standard No. 99 does not "address the need for, nor the form or content of, any retrievability requirements that might be appropriate, either during the period of waste emplacement or during a subsequent testing or observation period prior to final sealing of the repository". In agreement with the afore-mentioned principles, however, it defines a disposal system as "a combination of a geological environment, a repository and waste packages emplaced within the repository, without the intention of retrieval".

6. Conclusions

Neither the Rio Conference nor the CDS directly address the implementation of retrievability or reversibility as design features. The reference to international consensus documents, however, support the conclusion, that retrievability and/or reversibility is not requested as a design feature.

This avoids undue burdens on future generations by not relying on their means, ability and stable societal conditions to manage waste presently produced.

On the other hand, the relinquishment of retrievability and/or reversibility does not deny the right of future generations for responsible actions, including reparability and retrievability and even reversibility, at least for some time after closure. Future generations may also value a repository as a useful deposit.

On the basis of the above technical scientific and ethical arguments, retrievability should be avoided as a design basis of a geological repository. When retrievability and reversibility are requested, e.g., politically, interim storage - and not geological disposal- is an adequate technical answer.
The Issue of Retrievability

Steven Brown
Department of Energy
United Kingdom

I am conscious that coming at the end of the sequence, virtually everything that can be said has been said. I will limit my presentation, in which I present my own personal views, to a few observations and comments.

The UK is midway through a review of radioactive waste management policy. About three weeks ago the Government published its preliminary conclusions and these have been put out for public comment. The consultation ends in mid-October and the Government informed by the responses it has received will arrive at its final conclusions. As a side comment, I would say that "informed by the responses received" is not an attempt at consensus building as such. It recognizes, however, that there may be issues that we have overlooked or not given due weight to in our considerations. I cannot predict what the conclusions will be and as a civil servant I do not think it would be wise of me to speculate on its outcome. I will simply come back to the issue of retrievability in it.

The document does discuss the issue of policy for disposal and it does raise the issue of sustainable development in very brief terms. It does provide answers but also raises questions and invites views. The Government does, at least at this preliminary stage, continue to favour a policy of disposal rather than indefinite storage. It considers it appropriate to continue with the site investigation programmes that are underway in the vicinity of Sellafield. It also states that in the meantime the evidence as to safety and technology should be kept under review so that all can be satisfied that the eventual arrangements are the best means by which this generation can fulfil its obligations. The intention was a recognition that the strategy of the phased development with a number of decision points, which has been talked about on a number of occasions in the last day and a half, is the one that would be implemented with the policy of disposal. That is recognised. I would, however, caution against making a virtue out of a necessity. I think for any project, decisions to stop it can be made at any point during its lifetime. I would caution against raising expectations that there will be a major review at each minor step in the project and raising the expectation that you would have to refight the issue again.

The consultation document, which runs to about 100 pages, mentions retrievability twice. Once when there is the definition of disposal against storage, and which Dr. Bloser has referred to. A second reference occurs as part of the discussion on disposal versus storage. It makes reference to a study that was undertaken in the UK in the mid-80s called the Best Practical Environmental Options Study for Management of Low- and Intermediary Level Wastes. This study looked at whether it was appropriate to go for long-term storage or underground disposal or sea disposal. The study concluded that:

"deep disposal was the best practical environmental option for intermediate-level wastes. This includes alpha waste. If the balance of the argument was to be swung towards surface storage, it would be necessary to place a very high premium on the advantages of retrievability and reversibility."

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It then goes on to note that even with deep disposal the option of retrieval will remain open until closure of the repository several decades from the start of its operation. That is the only reference to retrievability. In the preparation of this workshop I wondered why we have made such scant reference to retrievability. I believed at the time that the issue of retrievability was one which should be framed in government policy or indeed should be a regulator requirement. On reflection, I do not believe it should be. Government policies provide a framework for an appropriate strategy to be developed under three broad policies:

1. That disposal of radioactive wastes is to be undertaken and hence a strategy would develop.
2. The alternative is that radioactive waste should be stored in a monitored and retrievable form;
3. To let the owners of the wastes decide which option they prefer to pursue.

Underlining all of this, of course, is that whatever is done is done within a regulatory framework to ensure safety. Therefore it is only the second of those policies where there is an obligation for retrievability. If that is the policy, then the operators would be free to develop a storage strategy as they wished. I doubt whether any would wish to develop a storage strategy deep underground. The costs would be prohibitive. If disposal is the general policy, the operator would wish to build in the notion of the fact that waste be retrievable for some portion of the operational life of the facility. But in proceeding with a disposal facility, its safety must surely be assessed in terms of a disposal facility. In the regulatory process this would need to be assessed at the time of the emplacement of the waste.

Whilst Mr. Lefèvre wishes to retain the right to be wrong, the chances of being wrong must be so remote for a disposal facility that retrievability should not be a requirement. There remains the issue of public confidence. That is something that has been referred to on many occasions and perhaps is one of the reasons for having retrievability. Rather than generating public confidence, perhaps this reflects lack of confidence in the integrity of the disposal facility itself. This is perhaps what we should be addressing.

In conclusion, I have come to the view that retrievability is not the central issue. It becomes a central issue where there is either a lack of perceived confidence in the integrity of the disposal facility, and that was something addressed in the earlier NEA collective opinion, or alternatively, when considering whether it might be right to say current generations for foreclose options for future generations to do with the wastes what they will. Policy of disposal does precisely that; it does foreclose options and we should recognize that fact and not try to shade the decisions or the definitions to try to pretend we are doing something else. In all our activities we do make decisions which will close options and we should recognize that as a fact.
Mr. Allègre

Si l'on se rapporte à la conclusion de M. Bloser, dont je me sens personnellement assez proche, je constate qu'en France le principe de la possibilité de réversibilité est dans la loi française de 1991 sur les déchets. Celle-ci dit expressément qu'on doit étudier un stockage réversible ou irréversible. Nous traduisons cela par le fait que dans nos laboratoires souterrains nous allons étudier en quoi consiste une certaine option de réversibilité. Je me suis exprimé sur ce point hier et ce matin et je n'y reviendrai pas. Mais nous devons nous demander pourquoi cette notion de réversibilité pour les stockages souterrains (je parle uniquement bien entendu des stockages souterrains) a pris ces derniers temps une telle importance? Et pourquoi nous ressentons à l'heure actuelle, en France tout au moins, une pression assez forte, pour ne pas dire très forte, en faveur de la réversibilité venant à la fois des opinions locales dans les régions où nous cherchons à travailler et implanter nos laboratoires souterrains et, également, des hommes politiques?

Personne en fait ne sait exactement de quoi il s'agit mais le principe de la réversibilité paraît être quelque chose qui permet de réduire la crainte, la peur de réaliser quelque chose d'irré médiable. Nous voyons là l'un des principaux problèmes que nous allons rencontrer, tout au moins chez nous, lors de ce fameux processus par étape dont nous avons maintes fois parlé au cours de ces deux journées.

(If we go back to Mr. Bloser's conclusion, with which I am in personal agreement, I note that the principle for the possibility of retrievability is found in the French act of 1991 on radioactive waste which expressly states we must study both reversible and irreversible storage. In our underground laboratories this will be implemented by studies to be undertaken to define one option of reversibility. I expressed myself on this very point both yesterday and this morning and I will not come back to it. We must ask ourselves, however, why this option for the reversibility of wastes deposited underground (and I am speaking only, of course, of underground emplacement) has recently become so important? And why, in France at least, do we feel fairly strong, if not very strong, pressure in favour of retrievability coming from both local public opinion, in regions where we are attempting to build our underground laboratories, and, as well, politicians?

In reality, no one knows exactly what retrievability means except that it may reduce the worry, the fear of creating something irreversible. This is one of the major problems we will have to deal with, at least in France, once this step-by-step approach we have repeatedly discussed over these past two days has begun.)

Mr. Lefèvre

Je ne reprendrai pas ce que vient de dire très bien M. Maurice Allègre sur la première partie de la réponse que je voulais faire à Steven Brown. Je crois que c'est tout à fait la réponse que je n'aurais pas faite aussi brillamment, mais c'est tout à fait le sens que j'aurais donné à l'expression que j'avais utilisée peut-être trop brutalement hier pour le droit à l'erreur. "Le droit à l'erreur" n'était pas le droit à notre erreur, mais le droit à l'erreur vue par le public s'il considère qu'on a pu faire une erreur. Ce n'est pas nécessairement une véritable erreur de notre part.

Je voudrais surtout revenir sur un point de définition de la récupérabilité, ou la réversibilité. Je crois qu'il y a plusieurs stades. Il me semble qu'il y a des positions qui sont un peu extrêmes. J'ai entendu parler, aussi bien par M. Bloser que par M. Brown, du stockage temporaire des déchets, qui peut évidemment paraître comme la forme la plus réversible. Quand on parle de réversibilité, il en
était d’ailleurs ainsi dans les discussions politiques en France, il s’agit de faciliter, la récupération des colis. Celle-ci peut être conçue d’une manière évolution. Elle est évidente au moment de l’exploitation du site du dépôt, puisque rien n’est encore fermé, et tous les accès sont disponibles. Progressivement cette réversibilité s’atténue, mais elle existe pendant encore longtemps. Au niveau de la conception du stockage, on peut penser éventuellement à une reprise, peut-être un peu difficile, mais la faciliter simplement. Je dirais que l’on peut simplement utiliser des colis de déchets qui ont une intégrité dans le temps suffisante pour qu’on puisse les récupérer même après que tout soit fermé. Bien sûr c’est un cas extrême. En définitive, et on l’a dit bien des fois, ce que l’on a fait peut toujours être défait et je ne vois pas en quel un dépôt parfaitement réformé n’est pas encore réversible. On peut toujours recréer là où l’on a déjà été creusé, et aller chercher les colis si leur intégrité le permet. C’est vraiment tous les stades de réversibilité et non pas simplement les deux extrêmes qu’il faut considérer.

(I will not repeat what my colleague Mr. Allègre has stated so well and which covered the first part of my response to Steven Brown. It is, I believe, exactly what I would have said, although not so brilliantly, and which reflects the meaning of the expression I used yesterday, perhaps a bit too harshly: the right to err. By "the right to err" I did not mean the right to make our own errors, but the public's perception of our right to err if it considers we have made a mistake. This does not necessarily mean a veritable error has been made on our part.

I would like in particular to return to the definition of retrievability. I think this involves several phases and it appears to me that some extreme positions have been taken in this regard. I have heard both D. Bloser and Mr. Brown speak of temporary storage of wastes, which clearly seems to be the most reversible form of storage. When we speak of retrievability, and this was the case in political discussions that took place in France, it involves facilitating the recovery of containers. This can be achieved in certain ways varying with time and is certainly possible when the site is in use because nothing is yet closed and the different accesses remain open. The possibility for retrievability progressively diminishes, but will exist for a long time to come. At the conceptual stage of the repository, we may foresee retrievability and, although such a measure might be somewhat difficult to take, we can seek ways to facilitate it. I would simply say that we can use waste containers that are sufficiently durable so as to be recoverable after the repository has been closed. This is, of course, an extreme situation. In the end, and we have repeated this many times, what we do can always be undone and I do not see why a repository that has been sealed cannot be reopened. One can always redig a new access where one has been dug and retrieve the containers if they have remained in good condition. One must consider all possible phases of retrievability and not simply the two extremes.)

Dr. Flowers

I do think that was a helpful comment. The idea of becoming progressively less retrievable under your control is quite a comfortable one.

Mr. Schaller

On the subject of retrievability, I would like to go a little bit further in the rational approach. As Mr. Lefèvre has explained one may have a disposal site which is closed totally over many decades, or even centuries, and then decide to recover the contents, provided of course that the packages are made in a resistant form. This implies a certain cost. On the other hand, if one creates an underground facility for final disposal, but want to leave open the possibility of retrieving the waste after a certain time, there are extra costs. It is necessary to keep open the galleries in a salt dome, to recut the shafts from time to time, there are all sorts of supervision costs, etc. These costs can be calculated and there will be a time when these additional costs to the real disposal costs, when the
galleries are closed, will be the same amount as the cost to go from the surface down and recover the packages. I call that a break even point. We commissioned a study on this point situated a few decades from now and analyzed the nature of the geological formation.

I believe retrievability is a problem in that we have not explained well enough to the public that keeping open a full disposal site creates a cost to society. On the other hand, waiting a certain time, the waste may be recovered at expenses that really may not be needed because future generations will perhaps decide not to reopen the repository. These are the options on retrievability we will have to explain to the public.

Dr. Flowers

Thank you for that. It means you have to have some feel for the cost of retrieval and it seems a very sensible way forward.

Dr. Van Enst

In The Netherlands retrievability is not a goal in itself. I mean that retrievability should not be seen as some trick or invention of the government guided by what the people think, to continue our research. In fact, you must take a step back and especially so in a discussion where ethics is the guideline.

The Government, if it wants to continue with nuclear energy, is responsible for a sound solution for the disposal of radioactive wastes. In years past, and I speak for The Netherlands, the Government and the people dealing with disposal did an excellent job, but lost control in convincing the public. Why is that? It is because there is only one solution and it is stuck to that solution. You told stories about that to the public and they were very good. Safety is ok; it is written down in the RWMC collective opinion and no one can say there is something wrong with safety. Why then does the public not agree with the Government's safety solution? In fact, it is not that they disagree with the government, but they have a feeling the solution is being forced upon them and that other solutions probably exist.

If you think, and this reflects the position in The Netherlands today, you need a different process to set your goal because the responsibility for finding a sound solution for radioactive wastes is still there, a clear process is needed. Once you have this process, you must step back and say if retrievability is really thought to be a possible solution, then it must be studied. If long-term open storage is thought to be a solution, we will study it and compare it, which in fact, is what we are now doing. We do not exclude salt from it. We want to study several disposal options, present the results and offer our opinion as to which is the best one; and maybe this option is retrievability for the next several years. That has to be found out. Then you try to create an open process in which people from the groups surrounding us can compete. I think this is one example of what D. McCombie said about leaving the options open and making it more incremental. Then I think you can go on.

Mr. Thegerström

In the sitting activities now underway in Sweden, we have had the same experiences as mentioned by Mr. Allègre. Two major items are always coming up in discussions with the public: the first is retrievability and the second, control and monitoring of the repositories. We have a big task to describe the different aspects of these. For the public, retrievability, control and monitoring are very much linked to their notion of responsibility. Too often the nuclear industry in describing repositories have given the impression that their desire is to make a repository, close it and then turn to other problems and forget about that repository. We get a strong reaction because of that.
If we make the effort to explain to the public that there are difficulties with retrievability, that it could conflict with a long-term passively safe repository, if the time is taken to explain this to the public, they will understand. However, they will still ask for some "token" responsibility; they will still ask that somebody set up a programme for the far future or plan for future long-term monitoring around the repository. This will be required, not to guarantee the safety of the repository, but as a sign of responsibility and as a kind of psychological assurance that it will not be forgotten.

Dr. Ahearne

I wanted to point out that in this discussion of retrievability there is slow progress. It is one thing when talking about what it is retrievable or giving assurance for retrievability before the repository is closed. This refers to the comment made on extra expenses.

There has been some discussion that after closure one could still retrieve the waste. At some point, as you go into the far future, the confidence that you could retrieve may lead to having confidence that human intrusion could be prevented. The intrusion aspect is something, at least in the United States, that has been very difficult to wrestle with. It has been a major issue with respect to the Environmental Protection Agency's administrative regulations, and the U.S. Senate has commissioned a study by the National Academy of Science on this problem, which Charles McCombie and I are presently working on.

There comes a point in the argument of greater confidence being created because the waste is retrievable and may actually generate less confidence due to the possibility that you have allowed for the possibility of inadvertent human intrusion.

Dr. Flowers

I would just say on that point that there ought to be room for both those options. It seems to me that the main defense against risk from inadvertent human intrusion comes from the improbability of inadvertently intruding at that particular spot at that particular depth. It does not depend too much on the engineering feasibility of retrieving if you really set about it with knowledge of what you were doing. It seems to me thus that you can have a low risk from inadvertent intrusion whilst still having feasible retrievability, so long as records of the position exist.

Dr. Röthemeyer

I would like to act as speaker for Mrs. Gundelach. She was pointing out to me that she thinks there is a difference between the pressure of social acceptance, which has been addressed by our Dutch colleague, and the question of ethical justification. I would like to encourage people from that field to comment on this point.

Mr. Allègre

Je crois que là précisément, c'est peut-être un endroit où les deux se rejoignent. Lorsque l'on parle de réversibilité, je pense qu'on se situe dans ce que j'ai appelé lors d'une précédente intervention, le temps présent. C'est-à-dire, les quelques dizaines d'années à venir ou un peu plus, mais guère plus, par opposition au temps futur éloigné. La réversibilité est un moyen de favoriser l'acceptation par le public, mais il n'y a pas que ce moyen. Il y a un autre moyen que nous essayons d'employer en France et qui rejoint l'éthique. C'est le fait que dans le même temps que nous étudions le plus à fond possible mais avec des délais de temps qui se chiffrent en dizaines d'années, le problème du stockage souterrain, nous ne manquons pas d'étudier parallèlement d'autres solutions possibles et, en particulier, la question de la transmutation qui peut modifier fortement la nature des
déchets si ces études sont couronnées de succès et peuvent passer à un stade industriel ou pseudo-industriel.

Je crois que l'éthique nous commande tout autant que la politique, pour la présentation vis-à-vis du public, de ne pas arrêter les travaux dans ces autres domaines. Ce qui nous paraît le point essentiel c'est que nous devons travailler dans tous les domaines et nous devons, en particulier, travailler très à fond, l'étude du stockage souterrain. C'est là que l'éthique nous impose de ne pas nous en remettre au lendemain.

Quant à l'éthique vis-à-vis des générations futures et la question de savoir ce que seront ces générations futures, nous n'en savons absolument rien. Ou biens se seront des hommes de cavernes et, à ce moment là, plus nous allons faire aujourd'hui pour trouver une solution qui ne leur demande de prendre aucune décision et qui leur donne le maximum de garantie, mieux nous aurons travaillé au sens de l'éthique, c'est-à-dire plus nous aurons fait un stockage souterrain étanche et sur lequel il n'y aura plus à revenir. Si ce sont des individus évolués, tant qu'ils auront conservé la mémoire du stockage souterrain, ils pourront toujours mettre en jeu leur technologie extrêmement évoluée pour reprendre des matières stockées s'ils le jugent utile, quelqu'en soit la raison. S'ils en ont perdu la mémoire, nous sommes ramenés au problème précédent.

(I think this is precisely where the two join. When we speak of retrievability, we place ourselves in what I described in my last intervention as being the present time. That is to say, within the next few decades or longer, but only slightly longer, as opposed to the far-term future. Retrievability is but one means to encourage public acceptance. There is another method which we are attempting to use in France and which is associated with ethics. This is the fact that at the same time we are seriously studying deep geological disposal, the results of which will be obtained only in several decades, we are also exploring other possible solutions. In particular, we are studying the question of transmutation which, if these studies are successful and can pass from an industrial to a pseudo-industrial phase, would significantly modify the nature of wastes).

Ethics just as much as politics requires, insofar as the public is concerned, that work in these different sectors continue. What seems to be an essential point is that we must work in all sectors while placing particular emphasis on underground disposal. Ethics demands we not put this off to another day.

As for a code of ethics towards future generations and the question of knowing what these future generations will be like, we know absolutely nothing. Either they will be cavernmen and thus the more we do today to find a solution that asks nothing of them while giving them maximum guarantees, we will have worked well in an ethical sense; this is to say we will have constructed a leaktight underground facility that will need no further work. If these future generations have evolved in a more sophisticated manner, as long as the knowledge of this underground facility has been preserved, they will always be able to adapt their more sophisticated technology to recuperate, if deemed necessary and for whatever reason, the contained materials. If they have lost trace of that knowledge, then we are back to the preceding problem.)

Dr. Smit

I would like to take up the challenge offered by Mrs. Gundelach concerning the relation between social acceptance and ethical behaviour. We have seen from the discussions yesterday that there are several approaches to the ethical issue of underground disposal.
Yesterday, it was asked whether disposal was ethically correct or not. If you phrase it that way it sounds like a scientific question which has an unequivocal answer. This answer will depend on the merits of the technical judgment of the geological disposal. That is one type of approach focusing on the merits of the characteristics of the disposal.

The other approach, also mentioned, is to include several views representing different groups within society. One of the questions in ethical behaviour, as someone said yesterday, is whether and under what kind of conditions principle objections may be overruled by some group in a country? I give an example of a contrary behaviour. In The Netherlands some people have on religious grounds objections of conscience for taking out insurance. One could then ask whether insurance is ethically correct or not, which sounds similar to: is deep disposal correct or not from the ethical point of view? This is not the way, however, The Netherlands has dealt with this issue. It has taken into account the religious objections of this minority group and has not overruled them, but made an exception. They do not need to insure themselves for a car against accidents or for pensions, etc. They must still, however, pay the money to the Dutch government that would have otherwise been paid to different insurance agencies; their position does not offer them any financial advantages. This is the second approach you may have. It does not mean that you follow what is imposed by some group within the population; it means, in this example, the ethical behaviour of a Government includes paying attention to and respecting the positions of minority opinions. Minority opinions should also be taken into account when dealing with questions as to whether deep geological disposal is ethically correct or not.

Dr. McComble

I propose to end the morning with a cartoon illustrating some of our discussion. We had the issue of the car and as you can see I have not made a Volvo, I have made a Fred Flintstone type car because that is very fashionable for movie freaks today.

It illustrates who is involved in the ethics of waste disposal. On the overhead are the good guys. This indisputably good guy with the blue suit is my regulator. I always draw regulators as looking like English policemen of the old type (who are strict, but fair, and also kind).

So the regulator is in there and he is trying to steer the car. If I make an overlay with the engine, the engine is (in Fred Flintstone style) very powerful, and everyone is worried that it is too powerful and that it is going to run away with the car. The pair driving the motor, of course, represents the implementor, which I normally draw wearing a hard hat.

Then we come to the public, the brake. I have drawn the public with a nice choice of colour (green). One is on the back and is very worried because he is trying to brake this car and he thinks he is too weak on the brakes. He is worried about his strength relative to the strength of the others. Some of the public are worried in this particular way. They may think they are on the car but that they are too weak to brake it.

There is another part of the public who thinks they are not even on the car and that the only way they might be able to break it is like the gentleman on the ground. That is where they see themselves, outside the car able to brake only by being under the wheel and terrified that they won’t be able to brake it because it will run over them.

The conflict then comes up, this can lead to another part of the public on the car. He is the one with the hammer; he sees other ways to do the slowing down process. That is why we implementors sometimes feel worried. Thank you.

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SESSION IV

FINAL DISCUSSION AND CONCLUSIONS
Final Discussion and Conclusions

Dr. Flowers

We begin the final session of this two day meeting during which we must draw some conclusions from the discussions we have had. These conclusions will be transmitted to the RWMC at their meeting next March and if the conclusions are sufficient they will form the substance of the collective opinion which we hope to agree upon at that meeting.

Bob Bernero of U.S. NRC is going to help us draw the conclusions and lead the discussion in this session.

Mr. Bernero

I have made some slides which begin with the questions you find in the programme. What have we heard? What should be revised or reconsidered? And, the corollary, what are the lessons learned?

There is a great temptation when you have the duty or the privilege of being a rapporteur to present what you should have heard: for me to present my own opinion and say "I am happy, there is a consensus." However, I assure you that my views are, insofar as I express them, premature. It would signal a closed mind if I simply said: here is what I got out of the workshop and that is it.

I would like to make several comments in order to stimulate final discussion so that the Radioactive Waste Management Committee, of which I am happy to be a member, could give careful thought to the results of the workshop when discussing our collective opinion.

I would first like to present my overall reaction because it is clear that we have received valuable contributions, and especially from those outside the nuclear waste technology circle as well as from those inside the circle. This is particularly true concerning the perspectives given on non-nuclear waste, on the need for reconsideration of societal ethics and intergenerational considerations which are very important in light of the very long time scales associated with waste. But I feel that no fundamental change is evident. I did not come away with the feeling, "Oh good grief! We have to start over." I did find many constructive positions and many significant reconsiderations, but I don't think I detected any fundamental change in the overall strategy of waste management. In order to display this, I would like to go over Colin Allan's paper which provided the introduction for this conference.

First of all, the overall radioactive waste management strategy is sort of an election that was conducted in many nations over the years. In general, in the first choice of alternatives of whether to contain and isolate or to disperse, the international consensus is to contain and isolate, and I think this is accepted by this workshop. On the condition that one can choose containment and isolation, deep geology is preferred over the others (although there are questions from time to time about interim solutions of surface storage for even great periods of time). It is fair to say that the overall strategy of deep geologic disposal is the method of choice. There are things that came out in the workshop that affect the criteria, the objectives, and the standards for that; the general strategy, however, seems to be acceptable.

The alternative of partition and transmutation is generally viewed today as not being a way to obviate waste disposal. I know of no strong or broad opinion that says it is feasible or practical for society to undertake full partition and transmutation, virtually eliminating all long-lived radioactive waste species.
The objectives of the overall strategy are, and I emphasize that I am tracing in shorthand the material as it was presented in Paper n° 1, to protect the health, safety, and the environment for present and future generations. In the discussions we had on intergenerational equity, there was a fairly broad understanding that we would not depend on discounting over ten thousand years or so as a means for not worrying about health effects ten thousand years from now. In general, there appears to be an understanding that avoidance of discounting over those long periods, giving equal weight to health effects in the future as well as now, is the right way to go.

To minimize the burden on the future is not only a consideration of safety but whether the control burden or responsibility should be laid on future generations. There is general agreement or acceptance of passive safety. That is why waste repositories are underground; that the safety of the isolation depends on the engineering and the geology to an extent that does not require or does not depend on monitoring and control. This is not to say that there would be no possibility of retrievability or monitoring and control to some degree. But they would not be depended upon. That is the interesting marriage of retrievability.

In my slide this morning I said "why retrievability? What is the reason for retrievability?" The reason for retrievability is, in large measure, to give assurance that we are not leaving for future generations a time-bomb. Something that we assert is of high level of confidence and therefore forget about it. No, we would leave records, we would leave markers, we would leave retrievability in the sense that this is post-closure; that you could at least have a clear idea of how to go down and remove that material if it was ever desired by that society. That seems to be a logical combination of the full measure of passive safety and the rationale for retrievability.

There is also an International consensus for a multibarrier system. In general, this consists of a stable waste form, long-lived containers, engineered isolation where the combination of things for emplacement is appropriate, whether it be some bentonite clay to surround the container or something similar, and of course good geological isolation. The one thing I heard about good geological isolation is a concern that some nations who have small areas and therefore very limited choices of geology within their borders may suffer a significant constraint. The approach of multibarrier system is a general and acceptable one from what I have heard at the workshop today.

One of the most important things is the Incremental decision process. (This was not fully demonstrated, however, there are some nations doing this and there are problems in the conduct of this in some nations.) This is more than tactics. This is a strategy. It is more than tactics because the design and the assessment of the final objective are refined as you proceed, as knowledge increases. There is an increased ability to refine the design, to redirect the design or even to abandon the location if warranted. That is what makes it strategy.

There is incremental review as the work progresses. As you go through the conceptual and technological steps of waste isolation, of the surface characterization that goes with screening or generally locating possible sites, of the inground characterization were you are getting more serious, you know that in order to go inground you will have to dig a tunnel or something similar, and thus the serious endeavour of site selection begins. We all know that the public must be able to see this. This strategy should not be a tactic to sneak up on the public but to refine the knowledge and proceed incrementally so that society can do this job with the commensurate care.

Finally, and this goes with the refinement, the construction and operation phase. In Paper N° 1 decommissioning is mentioned, just as is many other places, but I prefer the word closure. It is that act where society says: having dug all the tunnels, having emplaced all the waste, we now feel that this repository provides a satisfactory, remote isolation of the waste. There is nothing remaining but the plugging of the shafts, or passage ways, and the final marking before we say "now it is there
for whatever monitoring and retrievability may ultimately ensue. There is an ability there, there is a record of the facility, but we are satisfied we have installed a repository of adequate passive safety.

The final aspect of the process is an extremely important one. I heard a lot at the workshop today that is of great assistance in understanding the role of public involvement. In his paper, Colin Allan used the phrase "consultation with an active participation of a wide spectrum of society." You will recall that we have discussed host communities, the general community at large, the political community, the technical community at large, and the technical community specific to nuclear waste and nuclear technology. It is appropriate to have consultation and active participation with all of these people. In order for the incremental process to be effective it must also be open so that all these communities can participate.

There remains, however, a very delicate problem. Each national system must make the decision on things like voluntary siting, the appropriate method to fund the activity over the long term, and how the funds will be gathered and controlled. Is voluntary siting truly going to be voluntary siting or no siting? Is it veto power? Recall Charles McCombie's cartoon. Is the public sitting on the back of the car with the brakes on the wheels? Or is the public in front of the car and able to stop it with a veto? A good incremental process would, one hopes, avoid that issue. It is up to the national process to deal with that issue.

One thing we can all see, is that the incremental process openly conducted is the only hope of resolving that issue favourably. Some nations have already tried to select sites, or have selected sites, and you can see the reaction when it is done in the older fashion of decide, announce and defend. It polarizes and very nearly paralyses any activity.

Dr. Flowers

We have heard a very succinct résumé of the strategy of radioactive waste management disposal and how it seems to have stood during these two days of discussion.

We will open the floor now to that discussion and of course one of the things we are anxious to cover is the extent to which the perceptions of ethical right and wrong held by people in this room, at least, matches up against this strategy. We cannot fully cover the question of what is ethically right because we have learned that this must involve a much wider community than the people sitting around this table. It would, however, at least be helpful to know the views of the people here on the extent to which the strategy described meets ethical and moral principles as we understand them. In that respect, I think it has been helpful that we have had some general principles of what is ethically correct written down for us in papers, for example, by Mrs. Gundelach, Fred Roots and John Ahearne.

Dr. Peter Brown

I would like to make some general comments. I was, like Bob Bernero, very pleased about the last day and half. I think it has opened up many new perspectives in terms of how we should view waste disposal. My own view is that from an ethical point of view the waste strategies that we have outlined will hold up very well. We should be very careful, however, because, as I see it, there are three different levels of ethical views to be considered.

The first is nuclear waste disposal in isolation. We have discussed this and we have a very good strategy. Without presupposing the subsequent debate, my own view is that it has held up very nicely.

The second view, which brings in other parts of the ethical spectrum, is when we start making comparisons with other waste strategies such as mercury and other chemicals, in order to get a cross
comparison between strategies and to get things into a reasonable perspective. It is an exceedingly useful thing to do and what we have seen in the last day and a half is a very good start.

There is, however, a third level of ethical perspective, which some of the ethicists tried to capture: looking at waste disposal or waste management within a much larger context. For example, looking at waste disposal as one the problems related to energy production. To take this perspective, you need to take a comparative look at the different forms of energy production. What about flooding in terms of hydro generation? What about CO\textsubscript{2} in terms of fossil fuel generation? What about CO\textsubscript{2} and acid rain in terms of coal? Once you start looking at disposal in this sort of context you then get into a "good government" question. How do you want to spend your money? How best to spend your money? Should you be spending all of your mental energy and efforts on radioactive waste disposal, implementing a strategy, which may be a very good strategy to deal with hazards 10,000 years in the future, when the concrete hazard, for example, CO\textsubscript{2} is with us today. In terms of decision makers, this is the level of ethical argument that we have to get to in terms of how to spend our money.

I see these three completely different levels of ethical considerations. Over the last day and a half, the first level, the isolationist view, has held up very well indeed. We have moved successfully into the second level: looking at nuclear within the context of other wastes and other waste disposal strategies, and that should certainly be continued. I do not think we have really got into the third level at all, but I do believe that whatever opinion we come up with it should be seen within the context of this larger viewpoint.

Dr. Flowers

If I may comment, we should concentrate our minds on the first two. The third is an extremely important one, but not for us today. It needs an altogether longer time and bigger group of people.

Dr. Peter Brown

If I could just say that I was not proposing that this should be done today, but I do think that as long as we recognize it is within that larger context, then we will have achieved something.

Dr. Flowers

Can we have comments from people from outside the nuclear industry on whether they agree with Peter Brown that the strategy as defined holds up well against the general principles of what is ethically correct.

Mr. Roots

Yes, I do agree with the same caveat expressed by Peter Brown a moment ago. In attempting to answer the question "does the strategy stand up well?" we may have done a disservice to the broader picture you want to present in a formal Collective Opinion by giving expression to a certain defensiveness of what it is that the Committee has been focusing on for several decades when the ethical aspects, which strongly determine the reaction and acceptability by the public, are willy-nilly going to be put by the public into the second and third components that Dr. Brown just mentioned.

It is a bit unfortunate that in the last two days, with all good intentions, there were a rather large number of comments saying it is necessary to produce information that would convince "the public" of the soundness of this idea, a strategy based on technical information, when the best analyses that we can make show that there is no such thing as a unitary public. Part of the public, which is well informed and accepts all the technical detail, still will feel that technical, objective facts and communicated information are not sufficient to convince them, because the information does not
address all their concerns. These people really want to be convinced that there will be open participation in all the incremental decisions. This is, of course, what Colin Allan and Dr. Bernero mentioned about public involvement. They, the public, want to be assured that this involvement, not just receipt of information, is genuine. I think that focusing on rational arguments as a way of "convincing" may risk, I am being a bit radical here, the danger of the strategy being self-defeating.

The need to find common ground between those who are sincerely concerned about the future but don’t think that technical arguments are sufficient to deal with ethical and value issues; and those who feel that technical arguments in themselves are strong enough, is not incompatible with the strategy; but the strategy does not go far enough at this stage to deal with these different concerns. We have to realize when we are asking the questions as to whether it is ethical to dispose of the material in the way we stated, that ethics itself does not have subject borders. You cannot state it is ethical just to dispose of the waste without, as Dr. Brown said and others will be saying it also, looking at where the need to dispose and the disposal strategy fits in the larger spectrum of energy and industrial processes and other industrial controversies.

The answer to your question is "yes", but is too narrow a question to be useful to the kind of problem we have been discussing here. We have to put it into a broader context.

Dr. Flowers

Just to comment briefly on that, Fred. Suppose the nuclear industry were stopped today and we were asking you whether this is an ethical strategy for disposing of the wastes which we already have. What would be the answer to that question?

Mr. Roots

It would be ethical to the extent that we could say openly this is the best way we know how to solve the problem on our hands. That is honest and ethical, I think.

Dr. Lummerzheim

I would like to comment on the general question as to whether the disposal of the radioactive waste meets the ethical requirements, because this is not a task of the Ministry which I belong to, the BMFT, to state this. I would like to come back to a remark made by Mr. Brown from Canada and also to a question Dr. McCombie raised during his presentation this morning when he asked: "do we exaggerate the problem of radioactive waste disposal?"

I would like to draw your attention to the non-nuclear field which has been addressed several times. Facing the fact that we, at least in Germany, have per year ten million tons of chemical toxic wastes against four thousand tons of radioactive wastes, and taking into consideration that this waste consists of several thousand components that have no half-life and that the demands as regards the proof of long term safety are less rigid than, for instance, in the radioactive field, then I would say it is not possible for me to answer the question of Dr. McCombie of whether we exaggerate our problem. It is my personal feeling, however, that we are putting too strong an emphasis and effort on a minor problem of our society.

Mr. Bernero

I would like to return to the question put to Fred Roots a moment ago and to the earlier remarks made by Peter Brown. We have generally established that radioactive waste disposal in deep geology is an ethical choice for a society and that it is a separate choice to go to level three (the larger energy production and resonance context), as Peter Brown suggested. As to whether a nation which
has radioactive waste, has decided, in a broader picture of analysing nuclear technology against other available technologies, to have nuclear technology for energy independence, or, given an abundant supply of other resources, chooses another direction simply on the basis of cost, that is a separate choice. I think it very important to note that what we are addressing with the waste management strategy is not level 3. We are addressing that given that there is waste, or with the prospect of high level radioactive waste, is it ethical to future generations as well as to our own to have deep geological disposal?

Dr. Ahearne

I would like to address the question of whether an incremental approach is ethical. In response to the comment just made by Bob Bernero, to paraphrase Dr. Lummerzhein, the way you answered was too narrow.

Mr. Bernero, you addressed the question whether radioactive waste disposal and geological repository are ethical choices. If one is trying to address the issue of ethical choice, one must talk about the process by which the decisions are made. Much of ethics has to do with how people are being dealt with. I must say that I am part of the nuclear establishment and we, as technologists, always end up looking at an issue or problem as though it was the technology itself that had to be addressed. I argue again, it is the process by which we reach those decisions which has been so faulty in the past.

The incremental approach is fine so long, as the Dutch have pointed out, you do not see the incremental path as being a single path only. It must be possible to follow several paths depending upon how the choices work out as you go down them.

If, however, what you really have in mind, and this is where I believe the United States made such a gross error, is that the endpoint is absolutely known and so the only issue is how slow you move along to that well-fixed knowledgable endpoint, you have subverted the question of ethics.

Mr. Allègre

Je suis tout à fait d'accord avec cette affirmation. Le processus par étape est quelque chose qui nous est imposé par l'éthique. A condition effectivement que ce processus apparaîsse comme n'étant pas parfaitement défini à l'avance et que l'on puisse, à un certain moment, inférer le processus pour aller vers tel ou tel point. Il nous est également imposé par la pratique parce que la matière est tellement délicate au double sens de la complexité technologique ou scientifique, et de la difficulté d'explication et d'acceptation par le public, qu'on ne peut pas imaginer de processus qui ne soit pas de ce type. C'est pour cela que nous y sommes tous venus. En France c'est bien ce qui c'est passé, puisque après avoir voulu aller trop vite il y a cinq ans, on en est revenu à la définition d'un processus ouvert, par étape, réversible (si j'ose employer ce mot en ce qui concerne le processus cette fois et non le stockage) à tout moment. C'est celui que nous essayons de mettre en route en ce moment et qui semble pour l'instant vouloir commencer à fonctionner, mais je dois être extrêmement prudent dans mon appréciation.

Ce processus comporte bien l'étude de l'ensemble des voies possibles, y compris la transmutation-partition, même si nous pensons effectivement que même en cas de succès de cette méthode, cela n'empêchera pas le besoin de stockage souterrain. Pourquoi? Il y a beaucoup de raisons, dont au moins celle-ci: c'est qu'aucun processus n'est capable de fonctionner à cent pour cent. Donc, de toute façon, nous pensons qu'on aura besoin d'un stockage souterrain. Mais il reste à démontrer que le stockage souterrain marche et il faut donc de toute façon un processus incrémental pour cela.
Je voudrais faire une petite remarque en terminant. Je crois que finalement, comme vient de le dire M. Ahearn, nous faisons tous partie de l'"establishment nucléaire". J'ajoute aussi que nous étions probablement à peu près tous convaincus en venant ici que le stockage souterrain était quelque chose de "pas trop mal". Donc il n'est pas tout à fait anormal que M. Bernero constate qu'il y a une sorte de consensus sur cette idée-là.

Je me demande si nous aurions aussi bonne conscience si autour de la table il y avait une ou deux personnes de qualité (c'est difficile à trouver dans ce domaine), qui a priori ne soient pas tout à fait de cet avis, qui nous présentent des théories philosophiques correctement construites nous expliquant que nous ne devons pas être tout à fait aussi tranquilles que nous le sommes, etc. C'est simplement une petite remarque pour tempérer très légèrement l'enthousiasme que je partage par ailleurs totalement.

(I fully agree with this statement. Ethics imposes a step-by-step approach on the condition, of course, that this process is not completely defined at the outset and may be modified when necessary. This process is equally imposed upon us in practice because the subject is an extremely delicate one given both its technological and scientific complexity and the difficulty to explain this and gain public acceptance. We cannot do otherwise than implement this approach. It is why we are all following this approach. This is what has occurred in France since, after having proceeded far too quickly five years ago, there has been a return to a more open, incremental and reversible (if I dare use this word to describe the procedure this time, and not the disposal method) procedure. This is what we are presently attempting to put in place and which seems to be working. I must, however, be very prudent in making such a statement.

This procedure encompasses the study of all possible options, including transmutation-partitioning; even if this last option is successful, we still think underground disposal will be necessary. Why? There are many reasons, the least being: no process is capable of functioning 100 per cent. Thus, in any case, we think we will need underground disposal. It remains to be demonstrated, however, that underground disposal works and this necessitates an incremental process.

I would like to finish with a small comment. I think, as Dr. Ahearne has just said, that we are all part of the "nuclear establishment." I would also add that at the outset we were all more or less convinced that underground disposal was "not such a bad idea." It is not surprising then that Mr. Bernero observed a sort of consensus on this idea. I ask myself if we would all have such a good conscience if there were amongst us today one or two highly qualified people (they are difficult to find in this sector) who did not a priori share this opinion and were able to present carefully thought-out philosophical theories demonstrating that we should not feel so comfortable with this idea, etc. This is just an aside to slightly temper the enthusiasm which I otherwise share.)

Mr. Berkhout

I should like to comment on the suggestion that the third context (the level 3) in which ethical views ought to be considered is this wider context of the comparison of different energy options. There have been various attempts in the last ten years or so to do very systematic and comprehensive life cycle assessments of the various environmental impacts of the many different ways of generating electricity. In general, they have not been able to come up with firm answers. Setting the boundaries for such an assessment and agreeing on the values associated with different types of environmental effects, is always going to be extremely contentious because it is what will determine the answer. Obviously the people who are doing these assessments will always have a preferred answer. This kind of balancing has been attempted but it does not produce any clear cut solution.
I would also say that many decisions about energy policy are in fact not open to ethical considerations. Most of these decisions are determined by economic market considerations. The market itself is an institution, has already established certain ethical principles around economic efficiency so far as we can appreciate today with our technological capabilities and the way we value things monetarily and so on. Many of the decisions regarding energy policy are as a practical matter outside any ethical considerations.

What I have learned from this meeting is that there are two contexts for ethical consideration. The first is whether the strategy is right. That is ethics concerned with the technical implementation of a waste management strategy, and these ethical questions are primarily to do with intergenerational effects; the duties that currently living people have to people who are not yet living. The second context of ethics is within the whole decision making process. That is, the discussions and dialogue between groups of currently living people have to be conducted according to ethical principles. These two contexts are linked because they are concerned with the same fundamental problems. They will, however, be dealt with in different ways. The ethics concerned with a dialogue and how a dialogue should be conducted would be different than ethics concerned with intergenerational equity and how far we are permitted to pass on certain types of burdens.

Professor Catron

I would like to continue with the question raised by Peter Brown and then Bob Bernero’s, John Ahearn’s and Frans Berkhoult’s responses. I would like to make it as a methodological point distinguishing between technical discourse and ethical discourse.

Technical issues, such as comparing the physical features of possible waste storage sites, can often be addressed without raising larger questions. But ethical discourse typically does involve raising broader questions such as: what should societies be doing to reduce risks to current and future populations, for example, by exploring alternative types of energy production? What steps, such as research, should be taken to compensate future generations for the use of non-renewable resources used and ethical and safety burdens? Who should decide and how which groups should bear what risks? All of these are part of a broader ethical discourse which is quite relevant to the conversation we are having.

It is certainly understandable that this workshop has chosen not to address such wide ranging issues as these. However, it is important to recognise that these other elements can be very important aspects of ethical responses to environmental risks.

Mrs. von Rein

This meeting has been very good because it has forced me to reflect on the question of ethics and at the moment I am trying to sort out some of my thinking. I will present my personal view first and then I will try to relate it to the job I have.

What is ethics? Who is saying what is right and what is wrong? From our discussion today, I think that deciding what is right and wrong is built on values and attitudes. What is it then that gives us different values or attitudes? It is a complex question. There are different interests such as economic interests, political interests (people want to have power and decide) and social interests. It is based on knowledge and how to use knowledge as some sort of evaluation process. Values and attitudes are built on history, either the history of people or on the history of one person. If the person is in a position to decide he or she will be deciding according to their own personal history.

It also has a lot to do with human feelings, even if we don’t talk about feelings very often. The fear of people about what is going to happen in the future, that we do not have control over what
society is really doing. It is also about confidence. All the technicians here have confidence because of their knowledge and capacity to evaluate it; they can believe in their models. However, someone who does not have that knowledge must believe in the people they are talking to. This is where the communication problem comes in.

I think it has to do with values and attitudes we are planning for the future. How good are the thoughts we have and the creativity of our vision for the future. All of this is forming what we think of ethics today.

We have to accept to take responsibility. We have to take responsibility for how we choose to and how we want the world to be in the future. That is the level of ambition we are choosing for all these different questions and this has to be justified. Respect for human beings and nature is also very important.

I will now try to connect these observations to the situation in Sweden today. Insofar as mercury use and emissions are concerned, it is clear that we have a problem. In the southern part of the country the background levels of mercury are four to seven times higher than they should be. In the northern parts of Sweden it is two to five times higher. As I said yesterday, the fish have too high a mercury content to be edible. So it is a widespread problem; there is widespread contamination throughout the country and we must do something about this situation. This is tied to ethics; it is about the quality of life. Even if we cannot solve the problem today, we must start to act now. This is where responsibility comes in. We have to be responsible to do something about it. We also have to respect humans and nature when we are deciding what to do. When we are taking up our responsibilities we have to set up a strategy. In the case of mercury, this consists of reducing further environmental impact by human impact. You can do this by stopping its use and reducing emissions. We also have to take care of the waste we have generated. We have to take care that contaminated sites are not a threat to the environment.

Dr. Flowers

Thank you very much for that analysis. I think it throws the emphasis very clearly on to the process of consultation and diagnosis of opinions. Are there some comments on this?

Mr. Schaller

I must say that I do not like very much the comparison with the mercury case, a case where everybody sees an immediate danger for himself. Eating fish or having to eat food filled with mercury amalgam is increasingly seen as a threat to our own immediate health and to all generations. This immediate danger facilitates any decision because people have no choice. Whenever it has been stated that the acceptable amount we have in our bloodstream is higher than what is good for health, then everybody feels concerned and everybody agrees that the use of mercury must be stopped. They would also agree that the remaining mercury should go to deep disposal.

With radioactive waste disposal things are quite different. There is no urgency. We always tell people that if they do not like deep disposal we are able to store it on the surface. There is absolutely no danger. So I think from the ethics point of view there is an important difference between these approaches.
Mrs. von Rein

My intention was only to show how I was thinking about these ethical questions and then put it into the context of my work. If you want to see any similarities or not, that is up to the audience.

Dr. Flowers

You can't argue with that.

Dr. Zurkinden

I would like to thank and congratulate Bob Bernero for the positive conclusions he was able to make of this meeting. I personally did not have such a good feeling, but since his conclusions have not been contradicted I assume that they reflect the opinion of this audience. I can now go home with a better feeling.

Mr. Lefèvre

Je crois qu'on a déjà dit beaucoup de choses. J'étais intéressé par les niveaux d'éthiques que Peter Brown a présenté et moi aussi j'ai essayé de penser à ma façon. Je pense qu'on peut aussi présenter les problèmes d'éthique un peu avec le modèle de mathématique moderne des ensembles et sous-ensembles.

En commençant par le plus général, il y a l'éthique à l'échelle de l'humanité où on se préoccupe du monde, de son environnement mondial, de l'homme en général. C'est un peu ce que l'on a vu dans nos réflexions.

Il y a les éthiques nationales. Les pays ont une éthique qui est bien sûr incluse dans l'éthique générale de l'humanité mais avec des perspectives, des problèmes, des contraintes qui font qu'une éthique nationale peut être différente de la nôtre parce que les problèmes, l'environnement sont différents.

Il y a les éthiques professionnelles. Le médecin fait le serment d'Hypocrate, je pense que c'est valable dans tous les pays, mais l'éthique du militaire est différente. On a aussi un certain nombre d'éthiques professionnelles et il y a l'éthique individuelle.

Alors je répondrais en deux temps, parce que je suis un technicien du nucléaire, à votre question de cet après-midi : "est-ce que l'évacuation géologique est bonne?" Dans mon éthique de technicien je réponds oui. Je réponds oui avec cette nuance : je répète simplement très succinctement qu'on ne peut pas se contenter de cette seule option, et je ne veux pas répéter ce qu'a très bien dit M. Allègre tout à l'heure, il faut également regarder les autres possibilités, les autres options possibles du traitement des déchets radioactifs.

La question qu'on s'est posée est : est-ce que notre réponse dans notre éthique de spécialiste s'intègre bien dans l'éthique générale, celle de l'humanité par laquelle j'ai commencé?

La réponse est difficile parce que d'abord le débat ne nous appartient pas complètement. Ce sont bien sûr les hommes politiques à certains niveaux qui évalueront l'importance des différents problèmes à régler. En particulier, M. Charles McComble a demandé si nous n'étions pas trop ambitieux. Je crois qu'on peut traduire ça aussi par "est-ce-qu'on dépense pas trop d'argent sur nos problèmes?" C'est bien les politiques qui doivent en juger.
Dans l'éthique du spécialiste je crois que nous devons apporter aux politiques tous les éléments d'appréciation. A partir de là, les hommes politiques verront s'il vaut mieux dépenser plus d'argent pour la santé, pour lutter contre les maladies, et considérer dans quelle mesure ce que nous avons fait pour les déchets nucléaires est suffisamment satisfaisant pour arrêter de dépenser de l'argent. Je crois que ceci permettra de répondre à une éthique globale, mais nous ne pouvons pas nous-mêmes aller jusqu'au bout du débat.

(I think we have already discussed many things. I was interested by the different levels of ethics presented by Peter Brown and which I have reflected upon in my own way. I think ethical problems can be presented in the same way as mathematical problems with their sets and sub-sets.

To begin with the more general, there are ethics from the broad viewpoint of humanity which are preoccupied with the world, its environment and human beings in general. We have somewhat touched upon this in our reflections.

There are national ethics. Countries have an ethic which is of course included in the general sense of ethics of humanity, but from a perspective, with problems, with constraints different from our own because of the different nature of the problems and environment they are dealing with.

There are the various professional ethics. The doctor takes the Hippocratic oath, I think this is the case in all countries, but military ethic is different. There are also a certain number of other professional ethics and there is the individual code of ethics.

So my response to your question: "is geological disposal the right solution" would, because I am a nuclear technician, be twofold. As a technician, my answer is yes. I answer yes but with this nuance: I repeat that we cannot be satisfied with this option only and I do not want to repeat what was so well said by Mr. Allègre earlier today, we must study other possibilities, the other possible options for the treatment of radioactive wastes.

The question we have asked ourselves is the following: is our answer, given from our ethical perspective as specialists, comparable with the larger code of ethics, that of humanity, by which I began? The answer is difficult because first it is not solely up to us to give the answer. It will be up to certain politicians to evaluate the level of importance given to the different problems to be resolved. In particular, Dr. McCombie asked if we were not too ambitious. I think this can also be translated by "are we not spending too much money on our problems?" It is up to the politicians to decide.

As specialists, I think we must bring to the politicians our ethical perspective on the different facets of our problem. From there, politicians will be able to decide if the money is better spent on health programmes, to finding cures, and to judge whether what has been done in the nuclear waste field is satisfactory enough and thereby stop all expenses. I think this will allow for a more global answer on ethics, but we ourselves cannot decide on the outcome of this question.)

Dr. Flowers

I think that is a very good statement. The way I see it is that any collective opinion which is sent from the RWMC will be basically an opinion on the ethical merits as seen by the people in the nuclear technical community. We are trying here to test our views out against those of at least some people who are less directly connected to give us some confidence if it is deserved. In the end, the collective opinion will be only one of many inputs to the national governments brought by the members.
of the RWMC who are national government representatives. We expect and hope that those views on the ethics of our strategy will be taken into account in the debate.

Dr. Steven Brown

To pick up on Dr. Zurkinden’s point, I have found the past day and half extremely interesting and very valuable from a personal point of view in terms of the UK programme and our review of the radioactive waste management policy. The way the structure has gelled during the past day and half seems to have been that there is a hypothesis that the type of disposal strategy outlined or summarised by Mr. Bernero, is: “Is it ethical? Test that. Do we agree that it is ethical?” There is a general sense around the table that yes, it is. Nobody said it is not.

In a sense, everybody is working towards this sort of strategy. I think I could start nitpicking on certain aspects of that strategy but I would not want to. Is it worth posing the question, Mr. Chairman, the other way around? Is it ethical to pursue a policy of extended storage with no intention of disposing? That is indeed the strategy which is being put forward by opposition groups. It is also the default strategy which we will end up with if we are not clever or shrewd enough to be able to get a disposal strategy. I have heard nothing in the last day and half to say that an extended storage strategy would be unethical. I wonder if others disagree?

Dr. Flowers

That is not a bad idea. I have in mind Mrs. Gundelach’s paper where there is a simple sentence that says perpetual storage is unacceptable, on ethical grounds I presume. So there is one opinion. Let us just explore for a moment Steven Brown’s question.

The nuclear industry in the U.K. has said more than once that they would be content on technical grounds to pursue either long term surface storage or deep disposal, the choice is a political one. We have our political answer from the Department of Environment who would prefer we make plans for deep disposal. However, is there an ethical argument against the long term surface storage option?

Mr. Bernero

Although I did not hear a lot of discussion of it yesterday, it was my sense that the delegation or transmission of responsibility for dealing with waste, absent passive disposal, should not be given to future generations. There were remarks by Dr. Ahearne about funds that could be left as an endowment to take care of the problem. This fund, however, is certainly not possible in the United States where even the nuclear waste fund being collected today disappears very quickly in a deficit ridden Congress.

There were also some remarks to the effect that it is not ethical to leave an unsolved problem. Very long extended surface storage is, in my view, an unsolved problem.

Dr. McCombie

I feel the same way about extended surface storage. We had all these principles before and I think we have seen clearly that extended surface storage falls between two principles. It keeps choices open in a very obvious way, but it also changes the burden. We come back to Professor Catron’s question: “how do we balance the two principles together?” You can leave some burdens if something positive is also being left. If we assume that leaving a choice open to future generations is something positive, then we don’t have to solve all the burdens. How much do we have to solve?
A viable technical solution and funding are two things we have to find, a third is convincing the public, and, finally, comes implementation of disposal facilities.

My personal opinion is that we should have the first three but that it is not necessary to have the fourth. In other words, reduce the burden in as much we would put on the table accepted technical solutions. It is very nice and encouraging to hear that geological disposal is accepted for mercury. All we have to do is have it accepted for radioactive waste as the next step. The funding is regulated in some countries, acceptance has been achieved in no country, and the implementation will come afterwards.

Mr. Long

Let me just note some work that has recently been carried out by Resources for the Future in Washington. I will give them a plug because they have been doing some interesting studies. They took a look at the question "Is it ethical to transport hazardous wastes across state borders?"

They were unable to make the argument on ethical grounds, but they said it makes strong economic and environmental sense to make the transfer. The economic and environmental arguments in this case, at least in their view, seem to outweigh the ethics. As one takes a look at these options when you finally come to talk to the public about what makes sense, you are going to have to look at the economics and the environment while looking at the ethics.

The second point made by Resources for the Future, and I might have missed this Mr. Chairman because I was unable to be here this morning, concerns this whole matter of compensation. I heard no discussion yesterday on this subject. Resources for the Future has also been looking at giving compensation to communities to accept landfills and incinerators. There is more of that going on now with communities being paid to put in schools, parks, etc. It is a change and there is a good ethical question here concerning this type of approach. There is a growing literature on this subject that might be of interest to some of the participants.

Dr. Flowers

There was some comment this morning that we should not turn our backs on sites of poor communities if they have offered to accept the sites. If they are technically safe, we would be wrong to turn them down for that reason. It is clearly a sensitive issue.

Mr. Ahlström

The question as to whether it is ethical to have indefinite surface storage of spent fuel is really at the heart of the controversy. The nuclear industry is always accused of not having a solution to the waste problem and it is therefore unethical to produce waste through nuclear power operation. This is a widespread accusation and we have a long experience of dealing with this in Sweden. The legislation introduced in 1977 forbade the start of new nuclear plants unless it was shown that there was a solution to the waste problem. You had to show that the waste could be disposed of in a manner that is acceptable with respect to safety and radiation protection. This means to me that you are not allowed to leave something on the surface of the earth for future generations to guard. Neither the nuclear industry nor their opponents have really questioned that this legislation is reasonable. This tells me that leaving wastes in long-term storage requiring guards and maintenance for the indefinite future is not acceptable. I would be a little bit surprised if someone found such a strategy of indefinite guarding to be ethical.
Dr. Flowers

A very important point. Yet as Steven Brown has said there are groups who propose that as a policy. One has to wonder about their ethics.

Dr. Ahearne

I am always happy to hear people give Resources for the Future praise as I was associated with them for a long time and still am. I would point out that my colleagues there would certainly vigorously defend their wisdom in economic matters, but they would not try to push too far their ethical knowledge and how to treat ethical issues. The arguments they have made on the economic issues, however, are quite sound.

I would like to get back to Steven Brown's question. The issue is not permanent surface storage or indefinite surface storage, it is whether some mid-term storage is ethical or not. Ron Flowers mentioned that in the U.K. the nuclear industry said they did not have a strong preference on technical grounds alone; they could have either surface storage or geological disposal, the choice was a political one. In my country, the nuclear industry did not say anything like that, but rather it said it had to build a repository as soon as possible.

I said in my paper that I believe it to be quite ethical to consider a policy while, as Charles McCombie said, the necessary analysis is being done to develop the case that geological disposal is a sound technical approach. It is absolutely necessary to go through this kind of process before going ahead with the construction of the repository. I see no ethical problems, however, with having interim surface storage for several generations, the time it will take for this process to be completed.

Dr. Flowers

You did indeed make that point in your paper. I wonder if Colin Allan wishes to respond?

Dr. Allan

In many ways the driving force behind disposal, as opposed to perpetual storage, is concern that with this storage, institutional control cannot be maintained. In a global sense, there is ample evidence that we periodically lose control of institutions and this gives rise to concern about perpetual storage. The issue then comes down to the time horizon over which one can contemplate interim storage. The answer could be "we should move as quickly as reasonably possible", recognising that "reasonably possible" is still going to take several decades. So we will have a period of interim storage. John Ahearne's discussion of interim storage had a time horizon of perhaps fifty years and the time horizons we are seeing in programmes today are not that much different. On average, we are certainly talking about several decades.

The point I would like to leave people with is that if we can foresee the collapse of institutional controls, we can then postulate what we will do about it, assuming we had moved far enough ahead to be able to react quickly. The reality, however, is that you will not foresee the collapse of institutional controls. The question then becomes "is it better to take a precautionary approach in case such institutional controls collapse?" This could happen either through some violent type of activity or just through the normal wear-and-tear of society. When a given facility has been around for some period of time, people become familiar with it and lose a sense of care. We have certainly seen examples of this. The radiation incident in Brazil a few years ago, where an abandoned source lead to several deaths is but one example of a loss of institutional control. I offer that as a thought.
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Dr. Flowers

If I may also say to John Ahearne, even if what he called the mid-term option was economically and technically acceptable, it does not meet many of the criticisms which have already been voiced around this table. For example Per-Eric Alström's point about our obligation to set in place the end-game, as you would say, rather than just leaving that open for somebody else to decide. Once you have decided that it will not carry credibility unless you move towards it in a practical sense. These points have already been well made and they keep bringing you back to the strategy of proceeding in the direction which has been defined on a pragmatic time scale; being ready to trim it, to change it, each time you take a look at it as you go. This is the point at which we started yesterday morning.

Mr. Allègre

L'idée du stockage indéfini en surface, que nous appelons en France "entreposage", mais pour une durée très longue et en tout cas indéfinie dans le temps, est une solution qui nous est très souvent opposée. Les anti-nucléaires lorsqu'ils concentrent leurs tirs sur les déchets nous disent: "laissez-les donc en surface. Peu importe pendant combien de temps; de toute façon un jour la science aura trouvé une solution." Par parenthèse, il faut noter que dans le même temps que l'on nous dit que la science aura trouvé un jour une solution et que cette solution sera la transmutation, l'incinération, etc., on nous dit également qu'il ne faut surtout pas faire de retraitement. Je ne vois pas très bien comment on peut faire de la transmutation sans faire du retraitement et même du retraitement poussé. Enfin, c'est un détail en passant.

Pourquoi cette solution de laisser indéfiniment en surface n'est-elle pas éthiquement correcte? Je pense que Colin Allan vient de le redire fort bien et je l'avais dit hier dans mon papier: parce qu'il n'est pas possible de pouvoir compter sur la pérennité des institutions humaines pendant une période qui est de l'ordre du temps géologique. Qui dit stockage en surface, qui dit entreposage, dit surveillance et on ne peut pas compter que cette surveillance sera exercée correctement pendant des milliers ou des centaines de milliers d'années. Personne ne peut l'affirmer. Voilà la raison pour laquelle il nous faut absolument essayer de faire autre chose.

On retombe à nouveau sur le processus progressif et, ce que nous impose l'éthique à ce moment là c'est de faire le maximum pour aller dans la direction que nous avons donnée à ce processus sans être tout à fait persuadés que nous y arriverons; mais au moins faire le maximum pour aller dans cette direction et ne pas faire seulement semblant. Autant il est nécessaire de se hâter lentement mais sûrement, autant il ne faut pas avoir dans l'idée que c'est un moyen de retarder une décision que nous n'avons pas envie de prendre. Nous savons que la décision sera difficile à prendre un jour mais il faudra la prendre dans le temps présent. Le temps présente voulant dire demain, après-demain, dans dix, vingt, trente ans. Mais nous devons avoir cela en tête et faire tout ce que nous pouvons pour que, si un jour toutes les garanties sont réunies, etc., nous soyons à même de prendre la décision. Ne rien faire et se contenter de garder les déchets en surface en attendant des jours meilleurs, serait vraiment tout à fait contraire à l'éthique.

(The idea of indefinite surface stockpiling, what we call in France "entreposage" and which you call in English "storage"; for the long term and with no definite time period is a solution often presented to us as a better answer. When nuclear opponents attack waste management they declare: "leave waste on the surface. It is of little importance how long they stay there, science will one day find a solution." As an aside, one must take note that at the same time we are being told science will find the solution and that this solution will be transmutation, incineration, etc., we are also being told not to do any spent fuel reprocessing. I do not understand how one can do transmutation without reprocessing, and even advanced reprocessing. That is just a detail I mention in passing.)
Why is the solution of leaving wastes indefinitely on the surface incorrect ethically? I think Colin Allan has said, once again very well, why this is so and I myself said why in my paper yesterday: because it is not possible to count on the durability of social institutions for a period of time calculated along geological time periods. Who says surface storage, says surveillance and we cannot count on this surveillance being done correctly for the next thousand or hundred thousands of years. No one can count on such a thing. This is why it is absolutely necessary to do something else.

We fall once again on the progressive system and, ethics imposes this on us, must go as far forward as possible even if we are not sure the results obtained will be successful. We must, at least, make a real effort and not just pretend to do so. As much as it is necessary to proceed at a steady pace, it is just as necessary to keep in mind that this process is not a means by which to avoid making decisions we have no desire to confront. We know the decision will be a difficult one, but it must be taken in the present time. Present time meaning tomorrow, the day after tomorrow, in ten, twenty, thirty years. We must keep this in mind and do everything that is possible so that if one day all the guarantees are there, etc., we will be able to take that decision. To do nothing and leave the wastes in surface storage facilities while waiting for better days to come would be contrary to the code of ethics.

Mr. Bernero

I would like to clarify a point I made at the beginning of the summary presentation and identify a variant to this question of surface storage.

Let us consider momentarily that there is no further generation of nuclear waste in the nation. That there is high level waste in existence and no question of further generation, but rather what to do with this generation of waste. I said in the last slide of the presentation that there must be an incremental process for an ethical solution to waste disposal and that the national system had to deal with the decisions on voluntary siting, whether or not a local group or authority could veto a site, funding compensation, and paying for the institutional mechanisms to continue pursuing the problem on the issue of disposal. Everyone would agree that deliberately perpetual surface disposal is not ethical. It is simply passing on a responsibility to later generations. The problem arises as we look to the decades long considerations that go with an incremental process. We must recognise it takes decades, not years.

As we look at that, we must seriously consider how each society, how each national programme, chooses to fund the disposal of wastes. In the United States we will have twenty-five or thirty thousand tons of waste and six or seven billion dollars collected to take care of the problem. That nation has to consider what expenditures, what degree of compensation, what solution is ethical for our generation in our context to handle this waste. I think this is what we are really talking about, what are we doing in the meantime.

I would also like to add a clarification. There is pressure in the United States, primarily a legal pressure, to dispose of wastes promptly because the regulatory authority said almost twenty years ago that in order to continue licensing reactors there must be confidence in a solution to waste disposal. We have also publicly stated our confidence that interim surface storage is clearly safe for at least one hundred years. So there is a perception of the need for urgency, but the legal framework envisions an interim period of at least a hundred years as being possible.

Dr. Flowers

If we accept the views of Professor Catron and Frans Berkhout that you should not discount money values beyond a generation or two, then it becomes financially unattractive to go in for
perpetual storage because the eventual cost of disposal, if that is what you do in the end, is the same in cash terms. In addition, you must also pay for supervision and storage for those extra years. Almost certainly the provision which has to be made for such a policy is greater than it would have been for an earlier disposal. The only way that position becomes reversed is if you allow the person who is paying for the waste management to discount the cost hundreds of years into the future.

Mr. Roots

There is one point regarding the storage versus disposal question that I am surprised has not been brought up in our discussion on incremental decision-making. This is the incremental aspect of the scale of the depository, not necessarily the design or location of it. We know, for instance, that Sweden has a plan that one tenth of the accumulative waste will be locked on as a phase-one operation. But certainly we should consider the whole issue as to whether or not there should be one decision for a nation to make kind of a depository for all its wastes and go with that. Need it be all or nothing? While the decision process is incremental, it also has a scale aspect. We should consider options of whether or not we dispose of some, store the remainder until we learn of the pros and cons of doing a particular kind of disposal and on what scale. There may be merit in doing this, not only to find the economy but to test the technology and to learn about what is the effect in the underground of one central depository versus several smaller depositories. I would suggest, Mr. Chairman, that issue of the optimum scale of the repository and what is practical will be particularly important to non-NEA countries who look at the NEA Collective Opinion. This will be especially important to Russia and Eastern Europe who will have to have various ways of resolving the huge problem they have. The leadership will have to come from here. We should not neglect the fact that not only is the incremental decision-making one of timing and who makes decisions, but of the size scale of the operation and how it is designed.

Dr. Flowers

I am sure that is right. On a scale of many decades one has to wonder what chemical wastes might become candidates for a deep depository.

Dr. Ahearne

I wanted to respond to the implication made that permanent disposal in the geologic depository is much cheaper than some interim surface storage. I think the question has to do with the time scale one is talking about.

I certainly do not want to give the impression of saying that I am for permanent surface storage; I have been talking about a fifty to one hundred year period. In the United States we have now spent, and Bob Bernero would know the exact figure, close to three billion dollars on Yucca Mountain. I don’t think we would have come even close to running that kind of a cost up if we were doing an interim surface storage facility for a reasonable period of time.

I think the point that Fred Roots just made is very important. I deal with Russia and the other members of the former Soviet Union on radioactive waste management issues. They are struggling with what to do about the disposal of their waste and I think your RWMC collective opinion ought to be careful. If you have the picture that you must move ahead rapidly with geological disposal you may essentially end up saying pump it underground.

Professor Catron

I have heard John Ahearne’s argument throughout this day and half as primarily a plea for incrementalism which has been endorsed by other speakers as well. I think in some cases he has
been heard as making a plea for inaction, but I don't think this is what he means. It seems to me that if an interim surface storage strategy or a deep repository strategy is considered ethical, the same questions should be asked with respect to the risks that are being imposed, who they are being imposed on and over what period of time. Certainly the arguments about institutional controls speak very powerfully against long term or indefinite surface storage. That point has been well made and is well accepted, but I do think it is important that we make ourselves available to learn more in these coming decades. If we think about how comparatively new we are at this game in historical terms we might very well learn more in the next generation that will shape a more adequate response for the long term.

In particular, I wanted to pick up on Bob Bernero's comment the national system must make the decisions on voluntary siting, funding, and so forth. That is certainly true now but it need not be true over the next two generations, even one generation. It might become possible, and I think that we ought to leave open, and perhaps aim for, the possibility of a genuine international resolution of this problem. Certainly this body, in sharing the knowledge and experience of various countries and so forth, can over time put us in a posture resolving this problem collectively rather than by a country by country basis. Particularly given the fact that some countries may not have adequate storage sites. We should not rule out the possibility that international movement of materials and of disposal will in time be handled by an international body.

Mr. Van Miegroet

I wonder when listening to some of the previous speakers whether the argument of not trusting the permanence of institutions of control is not used as a basis for rejecting long term surface storage. I wonder if this is a good argument. After all, those who are making shallow land burial sites are using precisely the same type of institutional control over two, three or several hundreds of years which they consider to be sufficient. I wonder whether the real reason why some of us want to go rather fast is that we do not trust ourselves and even less our governments to keep the money we are presently generating available for when the time has come to build these very large and expensive underground facilities.

Dr. Flowers

Thank you. That is a new angle on the timing.

Mr. Ahlström

This question of interim storage and final disposal is not an "either/or" question. I pointed out in my presentation that we need both. We have had this strategy in Sweden, Finland and other countries, of interim surface storage at an early stage in order to continue with the work on final disposal. This incremental decision-making process is a sound approach that I endorse and it is compatible with the ethical requirements I have heard during this meeting.

Dr. Allan

I would like to make a brief comment on Professor Catron's observation on the possibility of an international disposal facility. Cooperation and work towards that can be a viable and desirable target, although it will certainly raise a lot of public concerns. It does not, however, solve the whole problem. If a given element in society regards deep geological disposal as unacceptable or unethical or environmentally unsound, that same element is almost certainly going to consider doing it in someone's backyard as environmentally unsound. It does not, as a consequence, resolve the whole issue. It can deal with issues of countries that have limited access.
I would like to add a more personal thought. I reflected on what Mr. Lefèvre said about personal ethics. One of the hats that I wear within my company is responsibility for managing waste management areas that are research sites. We have been storing wastes since we began those research sites and I can tell you I would had hoped that my predecessors had established disposal facilities one hell of a lot earlier. It would make my job a lot easier and would resolve a lot of other issues. Peter Brown is also wrestling with some other historical waste issues and I suspect that he shares my sentiments:

**Dr. Flowers**

I can understand that feeling and of course there are two ways of storing toxic waste. One is in the raw form in which they arise from a process or a piece of research and that is a very nasty thing to be handed by your predecessor. The other way is in a stable packaged form ready for disposal and that is more acceptable.

**Mr. Saltzman**

In some of the comments made this afternoon, there has been something of the flavour of describing a situation wherein because of legislation or pressures of industry, etc., we have on a national basis painted ourselves into a corner. It is then argued that a particular approach is ethical and alternative approaches may be less so because of this corner we find ourselves in. We should resist an ethics approach that is not robust, that is not considered to be the right one regardless of how we happen to develop our national programme. Some of the things I have heard this afternoon sounded like "this is where we are, and because of the corner we are in, the only way out is the way which is ethical under these circumstances, as compared to the others which are not quite so ethical."

**Mr. Schaller**

I am feeling concerned about this question of an international solution leading to an international repository. The experience we have in the European Community is illustrative. We are now twelve countries and we have a treaty that allows for free movement of goods, services and people and it was made very clear that there should be absolutely no restrictions. So, theoretically, it should be legally possible to bring wastes from one country to another provided, of course, the operator of the facility in the other country agrees to accept them. In reality, this is not true. All member states, with the exception of the very small ones, are trying to close their borders to any form of imported waste. They would, of course, accept to export their own wastes.

What does this mean? I keep telling government officials that in a normal scenario there will be no escape of radioactivity to the surface during the first twenty thousand years existence of a repository. Do you really believe that in twenty thousand years Belgium, Portugal and others will still exist? They know that, but for them there is politically no way they can accept the waste. The conclusion I am drawing is that the political situation is shortsighted. It cannot be otherwise because the politicians are representing people and they are elected for short periods and so they have only a short term view. They will have a short term view even for twenty thousand years. In practice this international solution, as good as it may be, is not possible. It is clear that only one deep repository would be necessary for the European Community, but we will certainly have six or seven. It is crazy, but it cannot be avoided.

**Dr. Flowers**

It may not even be crazy. The other point of that equation is that the job of transporting toxic waste is not a trivial one in economic terms. We should not exaggerate the difficulty of finding a
satisfactory geological site by convincing ourselves that you have to take it all to one point. I think one must bear this perspective in mind.

**Mr. Warnecke**

I would like to use the comments on the international repositories to bring to your attention a few aspects affecting the position of the IAEA. Mr. Schaller is right when he says that within the European Community there are great difficulties to get an international repository. It is not only true for the European Union, the same attitude exists elsewhere. Is this always the case and for how long will it be so? Opinions on this can change.

I would like to give an example illustrating the contrary of what was said by Mr. Schaller. The Czechoslovakian state had initiated plans for the construction of a deep geological repository. The two states were later divided into the Czech Republic and Slovak Republic. They still have, however, a uniform approach to deep geological disposal. This approach should not be discouraged and ethical reasons should not be imposed that forbid such transportation of radioactive waste beyond national borders. If states agree to jointly have activities in radioactive waste disposal they should be allowed to do so. The Agency encourages states to come to joint solutions particularly where the radioactive waste amounts to be disposed of in deep geological formations are so small that a repository is not justified. The Agency provides assistance in collecting spent radium sources in Africa and disposing them in a deep geological repository. It would not be justified that every African state, if no export is allowed, builds its own repository.

I have given a few examples to show that although in general transportation of waste across national borders is not desired, such an option should not be foreclosed if the receiving state has the capacity to deal properly with the waste and if both states have reached a mutual agreement.

There is another point related to the question of deep geological disposal and surface storage and to the scope of any collective opinion that is finally formulated in this area. I would like to draw your attention to a specific waste, that from uranium mining and milling. Some people may express the opinion that this is long lived waste. Before formulating decisive points, it should be very clear whether mining and milling wastes should be covered under such a collective opinion or not. My opinion of what we discussed here is that it is outside of our discussion, but that should be very clear.

**Dr. Flowers**

There is no doubt that we would exclude that from our considerations. The wastes that we are talking about are not just long-lived, they are of certain concentrations as well. We will try to make that clear.

**Dr. Allan**

I have a point to make and a question to ask. I was struck by Mr. Schaller’s comments about the short term horizons of politicians and in many cases of a lot of us. It lead me to think that if we do not have a conviction to continue with a strategy we believe to be right, and an element of that strategy is interim storage, if we don’t make progress towards what we believe is a good end point then the next generation that follows us will surely have no more incentives to continue along that path. One has to be concerned about interim storage without a concomitant strategy of working from storage towards disposal.

I would like to pose a question: earlier the statement was made that the people around the table were members of the nuclear community and therefore it is not surprising that there is uniformity of thought. I thought that one of the objectives of this meeting was to get outside input so that we had
a more balanced view and test our ideas against a wider spectrum of thinking. I would suggest that we should ask our guests whether they consider themselves a member of the nuclear community or not to see if, in fact, we have tested our thinking against a wider community.

Dr. McCombie

On the issue of an international concept, we have stated officially in our declared strategy in Switzerland that this is one line that we intend to look at continuously in the incremental process. The pessimism of Mr. Schaller is certainly true today, but maybe in ten or twenty years it may be different.

I would like to point out, however, that the reasons for looking at international strategies are not, as Bob Bernero alluded to, due to small areas or geological restrictions. The reason is economic optimisation. All small countries I know have potentially suitable geology. Switzerland has actually looked at more geological options than some much larger countries where geological scoping studies have been restricted to sites belonging to the nuclear industry or the State. It is not a geological issue which is driving such countries. I am not saying that in a defensive way, but because there is an important mission behind it: do not start giving the impression that you can optimize in a geological sense by going over national boundaries. Looking for the best geology in a supranational environment is not the reason for looking for international solutions. I would like to make that very clear.

Mr. Bernero

I would like to make a clarification. As Charles McCombie suggested, the remark I made concerning limited choices was referring to economic restrictions. By way of example, the United States now has an inventory of 25 thousand tons of spent fuel. Yucca Mountain, which is a geometrically limited site, was after proper characterisation found capable of holding only ten thousand tons of spent fuel and there is serious question about whether it is worth developing. The economics of the project are very powerful considerations. The developmental costs, the institutional costs are massive compared to the incremental cost of putting another ton or two. We should be grateful that Luxembourp doesn't have one very small reactor. The institutional costs would swamp it. We have had serious difficulty in the U.S. with low level wastes because for policy reasons we separated low level waste disposal to many groups of states. Each of them has to pay large institutional costs to develop the site; costs which have skyrocketed the price of low level waste management.

One final remark. There have been some comments that transboundary shipment of high level waste could be a reason not to go from one country to another. Coming from a nation that is at least as large as Europe it the environmental impact or risk of transportation is so dominant as to prevail in that, then there is something wrong with the standards. Bulk transport in internationally accredited containers does not pose that kind of a risk. It is often perceived as a risk, but it does not really pose that risk.

Dr. Flowers

I should say since I mentioned the complexity of transportation that I in no sense was suggesting that it was a risk question which might cause you to avoid it. I think it is an economic point, exactly as the development of repositories is an economic point. If an international repository together with the transportation that goes with it is the cheapest option of a number of satisfactory options, there is no reason why it should not be adopted. There are, however, many political barriers to doing that at the moment.

I want to draw the meeting to a close. Before I do so, I would like to ask the Director of the Environment Directorate, Mr. Bill Long, whether he wishes to say anything.

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Mr. Long

I would like to make two brief observations. First I would join my colleague Mrs. von Rein in saying that this discussion has been very instructive. I said at the outset that I had not yet heard a good discussion on ethics, equity and intergenerational issues and, for our own purposes in the Environment Directorate, the discussions over the past two days have been very helpful. However, I have been worrying about Dr. Uematsu and his people and how this discussion will assist them when developing their collective opinion. I will give you a few of my own impressions as to what would be saleable to the clients we deal with.

When one thinks of the questions that come up when discussing deep geological disposal, the first assertion is that it is not an ethical thing to do. The strongest rebuttal to that argument would be to say that the issue of ethics and intergenerational equity have now been looked at and the most unethical attitude would be to take no action. The wastes exist and will continue to exist in the future and must therefore be dealt with.

The rejoinder one would expect to get is "Yes, but you are talking about putting the stuff down a hole. After over three decades of environmental experience we have seen that this has not worked with other waste problems. This "out of sight out of mind does not work". Your response would be (at least I hope it would be) that "We are not putting the wastes down a hole, but in a repository". To the extent that you can say that this waste is carefully monitored and retrievable, this would be a very important rebuttal to that argument.

The difficult part, however, is when somebody says: "Ok fine, you are going to put it down the hole, you are going to monitor it, but in the meantime nothing else happens". The nuclear community might well quit looking for technological improvements so that we will virtually eliminate waste or get rid of the waste by other means. Someone mentioned earlier today that surface storage is not the best solution because people should not be led to believe that new solutions will be magically found. If that is in fact the argument, this means that nobody is hopeful you are going to find any better technological solutions in the future. I do not believe most citizens would want you to draw that conclusion at this point.

This matter of technology, and the ability to argue that while the waste is being stored, better ways are being studied, is very important. It is important to demonstrate that the ultimate solution is not to keep drilling holes and burying more and more wastes. I believe, however, that all of those issues have had a decent airing in this meeting, and that you have enough "ammunition" to anticipate and deal with most of the hard questions you will undoubtedly continue to face in working toward a collective opinion which will attract widespread support.

Dr. Uematsu

I have participated at this workshop yesterday and this afternoon and I see many familiar faces. Someone has said they expected to see more outsiders participating at this meeting, but apparently this was not possible. Nevertheless, the participation of the Environment Directorate and the possibility to compare their problems to ours was very encouraging and helpful for our future activities. We have also had different groups of people to discuss the ethical problems of long-lived radioactive waste and it is with great interest that I listened to their arguments.

It is, of course, not any easy task to come to a conclusion, but at least we had the opportunity to discuss the ethics of adopting a strategy of direct disposal or of interim storage and our own responsibilities concerning these strategies to present and future generations. The questions raised cannot be immediately answered. As someone has already said, this depends on decisions made by politicians, a point I made in my opening remarks. However, significant amounts of waste already exist
and we should be doing something about this. The technologists have some answers, but they are
not necessarily accepted at the moment. This discussion will hopefully help towards resolving the
questions raised and, at least today, I feel that this has been the case. I can leave this room with
some peace of mind and I hope that is also true for you all. I thank you very much for your
participation at this meeting and I expect that useful proceedings will come out of this meeting.

Dr. Flowers

It is not necessary for me to make a summary because this afternoon’s session has been all
about summing up what we have heard. I thank Bob Bernero for that. The NEA Secretariat will
proceed to document the papers and discussions into a form which, after you have seen it, we hope
will be published. We then hope to proceed through the RWMC to a collective opinion and, of course,
your representatives on that committee will have ample opportunity to discuss that. For those of you
who are not members of the RWMC there may well be merit in your communicating with your national
representative on the RWMC your views of this meeting, so that they are well briefed to support or
otherwise any draft collective opinion which we may put to them.

It remains for me to thank the invited speakers for all the work they did in writing and
presenting their papers and to thank all of you for your participation in the discussion. I wish you a
safe journey home. Thank you.
ANNEX I

RADIOACTIVE WASTE MANAGEMENT COMMITTEE

BACKGROUND DOCUMENT FOR THE WORKSHOP ON THE ENVIRONMENTAL AND ETHICAL ASPECTS OF LONG-LIVED RADIOACTIVE WASTE DISPOSAL

Paris, 1st-2nd September 1994
ANNEX I

RADIOACTIVE WASTE MANAGEMENT COMMITTEE

WORKSHOP ON THE ENVIRONMENTAL AND ETHICAL ASPECTS OF
LONG-LIVED RADIOACTIVE WASTE DISPOSAL

BACKGROUND DOCUMENT
(Prepared by the Workshop Programme Committee)

SUMMARY

The present paper has been prepared as a background document to assist in the preparation and conduct of a workshop sponsored by the Radioactive Waste Management Committee (RWMC) of the OECD Nuclear Energy Agency (NEA) on the environmental and ethical aspects of the disposal of long-lived radioactive waste. Such issues may not have been explicitly considered so far to the same extent as technical issues and there is a need to have an in-depth review of their meaning and significance for the management of radioactive waste, including a broad environmental protection perspective. The purpose of this background paper is:

- To set the scene for the workshop discussions through a brief reminder of the main elements of current radioactive waste management approaches, their general environmental and technical bases and the principles which have led most countries to recommend the long-term isolation of radioactive waste under passive conditions in deep geological repositories; and

- To identify for discussion at the workshop a list of non-technical environmental protection and ethical issues raised by the management of radioactive waste (and other hazardous wastes), such as liabilities to future generations in a "sustainable development" context and the application of this principle.

The focus of the workshop will be the concept of deep geological disposal and the associated non-technical issues identified in this document. Invited specialists in environmental protection and ethics will be asked to address these issues and, to the extent possible, offer practical guidance regarding their resolution. Ultimately, the results of the workshop will be published by NEA and used by the RWMC to discuss the appropriateness of the concept of geological disposal of radioactive waste in a broad environmental and ethical perspective. The conclusions of the RWMC review will constitute its next "Collective Opinion".
I. INTRODUCTION

The development and welfare of modern societies depends to a large extent upon the contribution of technology and industrial processes, such as electricity generation. These processes are in general associated with the production of wastes, some of which are hazardous and require careful management systems in order to ensure adequate protection of man and the environment. The timescales over which such protection is required often extend well beyond the period of direct concern to current or forthcoming generations. Hence the ethical imperative to care about future generations and to afford them the possibility of enjoying the same choices and options which we currently enjoy. Such a concern for the protection of human health and the environment in a developing world led to the concept of "sustainable development" which was chosen as the main theme of the United Nations Conference on Environment and Development, in Rio de Janeiro in 1992. While this concept can be defined in relatively simple terms, such as "satisfying the needs of the present without compromising the ability of future generations to meet their own needs", the implications of the concept for individual industrial sectors are not always well understood.

The production of radioactive waste resulting from the generation of nuclear electricity and the various applications of radioisotopes in medicine and industry is typical of such a situation. It is a complex issue combining technical and scientific requirements with ethical considerations associated with the long-term protection of the environment. This issue was recognized by those involved in the nuclear industry who had chosen at an early stage to look carefully at the management of radioactive waste, because of:

- the nature of the hazard: the risk of ionizing radiation; and
- the persistence of the hazard due to the presence of very long-lived radionuclides in the waste.

The long-term management of radioactive waste is however only one example of a situation where the future environmental impacts of current practices for the disposal of hazardous waste have to be evaluated and regulated. Logically, the disposal of radioactive waste should be based on the same general environmental protection and ethical principles as those which may apply to similar situations in other fields, recognizing both the existence of specific categories of hazardous waste imposing their respective safety, environmental and technical constraints, and the desirability of promoting coherent and integrated risk management and environmental protection policies.

Against this background, the Radioactive Waste Management Committee of the NEA decided in 1993 to broaden the basis for an in-depth reflection on long-term waste disposal issues, notably on the fundamental environmental protection and ethical aspects involved, and to prepare a new RWMC Collective Opinion (i.e., a well-documented consensus statement written for a wide audience) on the appropriateness of long-term waste disposal strategies seen from a non-technical perspective. Indeed, such aspects have not been analysed and explained to the same extent as technical issues and may, therefore, not be fully appreciated. Furthermore, radioactive waste management has been largely developed at the initiative of the nuclear industry and nuclear regulatory authorities, without much interface with other industries and environmental agencies facing similar issues. Obviously, there is a need to broaden the discussion bases to include a more general consideration of long-term management of hazardous wastes. As an initial step in this process, the RWMC decided to organise a workshop to review the information available, stimulate an exchange of views between radioactive waste managers and specialists on ethics and environmental protection, and provide a sound basis for the drafting of the next RWMC Collective Opinion.
II. PURPOSE AND SCOPE OF THE DOCUMENT

The present document has been written to assist in the preparation of the workshop, notably in focusing the discussion to key non-technical issues which play an increasing role in the definition and acceptance of radioactive waste management criteria and strategies, particularly with regard to the disposal of long-lived radioactive waste.

Its first objective is to set the scene for the workshop's discussion and, therefore, to recall the main points behind the radioactive waste management approaches followed currently in most countries and the broad consensus which exist on long-term safety and technical issues at the international level. In particular, the general environmental and technical bases and the fundamental principles which have led most countries to recommend the long-term isolation of radioactive waste under passive conditions in deep geological repositories, are presented as background material. The deep geological disposal concept and possible alternatives will actually constitute the focus of the workshop.

The second objective of this document is to identify the associated environmental protection and ethical issues which invited experts will be asked to address in well-focused presentations and, to the extent possible, provide practical guidance on each of them. This guidance is requested to assist the RWMC in reviewing, reconsidering and restating a consensus on the radioactive waste disposal strategy.

In this context, although the proposed debate may be seen as an integral part of discussions on wider energy and environment issues, the document does not cover the environmental acceptability and justification of nuclear and other energy production systems, which are affected by broader considerations notably of the potential benefits and costs to society. It was not considered appropriate, given the mandate of the RWMC, to review such issues in any detail. In addition, radioactive wastes already exist, and continue to be produced as current applications of nuclear power and ionizing radiation are generally considered beneficial. Issues specific to their management and disposal need, therefore, to be looked at separately from the processes of their origin. However, broad cost/benefit considerations have a role to play at the workshop, particularly in the contexts of choice of strategy and of intergenerational equity, and they will be part of the debate.

The document and workshop do not deal in any detail with specific features of licensing systems and regulatory review processes, such as the setting of safety standards, consultation and decision-making procedures, the use of independent peer reviews, etc. Similarly, perception, communication and other social and public acceptance aspects related to the practical implementation and siting of specific waste disposal systems are not covered either. It is recognized that such aspects are important and can be strongly influenced by the debate on ethical and environmental considerations. However, their inclusion in the workshop scope would divert the attention from the more fundamental and generic issues identified later on in this paper.
III. BACKGROUND ON RADIOACTIVE WASTE MANAGEMENT APPROACHES

This section is a brief description of the approach currently favoured in most of the advanced countries for the management of radioactive waste. It summarizes the general thinking which has evolved in this field on the basis of several decades of research and development efforts, as well as intensive discussion at the international level. The strategies followed at national level are influenced by specific institutional and technical conditions, but they are in general relatively similar.

1. Nature of the Problem

The production of radioactive waste from the nuclear fission process as well as from other applications, for example in medical and industrial activities, results in a wide range of different types of waste products. Some of the waste are long-lived and persist for many thousands of years (such as the nuclear spent fuel itself and the most radioactive waste resulting from its reprocessing), some are short-lived and decay rapidly and become harmless in periods of time corresponding to human life or a few centuries at most. Because of the technical difficulties of modifying the nuclear properties of radioactive materials and, therefore, of diminishing their inherent radiological toxicity, there is no practical means today to avoid or reduce significantly the production of radioactive waste from nuclear fission. The potential for the safe reuse or recycling of some of the elements contained in the waste is also limited. Current studies on the separation and transmutation of long-lived elements present in the waste, such as actinides, are still at a preliminary R&D stage and are unlikely to result into the development of a full solution to the long-lived waste problem. Radioactive wastes have therefore to be managed as such, after suitable chemical and physical treatment to facilitate their handling, storage and disposal.

The relative hazards of radioactive wastes vary according to the nature and particular characteristics of the waste. They are associated essentially with the ionizing radiations emitted by their constituents, and their potential impact on human health and the environment. A great deal of experience with radioactive materials has been accumulated and the current radiological protection principles and regulations provide a good basis to ensure a careful and safe management of radioactive waste.

In practice, two main options, often complementary, are available: to contain and isolate waste from man's environment for as long as may be necessary; or, where practicable, to allow dilution and dispersion in the environment at levels which do not constitute unacceptable radiation risks. The latter option concerns in practice only a very small proportion of the total amounts of radioactivity present in the waste. The nuclear industry has chosen containment and isolation as its preferred strategy for long term management of toxic wastes.

In the case of dilution and dispersion, the presence of radionuclides in the environment represents a potential human health hazard, but one which can be adequately controlled on the basis of current radiation protection criteria. Some impact on the environment itself cannot be totally excluded, notably concerning individual members of living species, but this usually remains negligible when human health is adequately protected.

Various technical means, either temporary or final, have been developed for the containment and isolation of radioactive waste, ranging from interim short-term storage with varying degrees of surveillance and maintenance by man, to final disposal solutions requiring no further intervention by man or institutional control measures. For the relatively large volumes of low-level waste essentially free from long-lived radionuclides, an acceptable disposal solution is the emplacement of waste in near-surface facilities which can be monitored up to about 300 years, the time necessary for almost all the radioactive substances in the waste to decay to innocuous levels.

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The major issue is the existence of long-lived radioactive waste remaining toxic for extremely long periods, as compared to human and historical timescales, and requiring, therefore, isolation from the biosphere for comparable periods. Surveillance and monitoring by man cannot be assumed for such long periods and long-term containment systems have therefore to be passively safe. Ultimately in a suitable disposal site, when most of the radioactive waste content has decayed, some dispersion and dilution of the residual radioactivity in the environment may take place without appreciable risks. Although this long-term aspect has always been recognized and given prominence in the context of long-lived radioactive waste, it is actually present also with some other hazardous waste products, such as those containing toxic heavy metals, whose toxicity does not disappear with time. It would be logical, therefore, that the principles for the long-term disposal of radioactive waste be more or less the same as those which should apply to some other non-nuclear hazardous waste materials.

2. Basic Objectives of Radioactive Waste Management

Ethical considerations, notably for the protection of future generations, are an integral part of radioactive waste management principles. Liabilities to future generations and intergenerational equity were at the basis of the requirement for the long-term isolation of radioactive waste identified as early as 1957 in a report by the US National Academy of Sciences, which suggested that geological disposal would be the most promising method for that purpose. Disposal in deep and stable geological formations, could offer a passive system of multiple natural and man-made barriers between waste and the biosphere, remote from man and rendering human intrusion into repositories relatively unlikely, and with an inherent degree of safety so high that it would not require any form of institutional control. The scientific and technical character of R&D activities which followed in many countries had the effect of presenting the geological disposal concept as mainly technological, while its ethical basis and the associated ambitious safety level which were taken for granted by specialists in the fields, were often unnoticed and sometimes even ignored.

In this context, the objectives of radioactive waste management can be stated as follows: "to manage radioactive waste in a manner that protects worker safety, public health and the environment, now and in the future, and to do so in a manner that minimizes, to the extent possible, the burden placed on future generations". Emphasis is placed on safety, both radiological and non-radiological, protection of present and future generations, limitation of burdens to future generations, protection of the environment and preservation of environmental resources, as is illustrated in Appendix 1, which reproduces a more or less final version of waste management principles to be adopted by the IAEA. Existing levels of natural radioactivity in air, water and soil, provide a useful baseline which can be used for comparison of concentrations of radioactive and other toxic minerals in the geosphere and the biosphere.

A fundamental postulate of radioactive waste disposal is that future populations should enjoy the same degree of radiological safety as that acceptable to current generations. In other words, current radiological protection criteria are used as a reference to decide whether potential effects on populations living in the far future would be acceptable, irrespective of the date of occurrence of such effects. Today, the safety of disposal in deep and stable geological formations is assessed over periods of the order of 10 000 - 100 000 years or more, taking into account uncertainties introduced by the theoretical nature of risk calculations and the evolution of societies.

Other disposal concepts have been considered in many countries and even at the international level. They included burial of canisters in polar ice sheets, space disposal and disposal in the sub-seabed, a form of geological disposal in seabed geologies. For various technical and institutional reasons, these concepts do not enjoy much interest now, and deep geological disposal on land has become the central strategy in practically every country for long-lived radioactive waste.
3. Long-term Safety Issues

As potential long-term hazards are explicitly acknowledged, as well as the need to care about future generations, a prerequisite of radioactive waste management is that the long-term safety of a disposal solution must be convincingly shown prior to the implementation of this solution.

In the last 15 years, considerable efforts have been made to evaluate the behaviour of deep geologic repositories with time and their long-term safety. Scientific methods do exist today to establish the safety of particular disposal sites and there is an international consensus among experts that "appropriate use of safety assessment methods, coupled with sufficient information from proposed disposal sites, can provide the technical basis to decide whether specific disposal systems would offer to society a satisfactory level of safety for both current and future generations". This was the conclusion of an International [NEA/IAEA/CEC] Collective Opinion published by OECD in 1991 and reproduced in Appendix 2.

The existence of uncertainties in safety assessments is recognized, both in regard to physical data inputs and in judgements on the state of future societies, and appropriate allowance is made when applying the results of safety assessments. Nonetheless, the credibility of the geologic disposal objective and its practical realization involve value judgements, and there is a need to discuss the ethical considerations involved.


Most disposal plans for long-lived radioactive waste foresee the opening and operation of the first geologic disposal repositories around 2010-2020 at the earliest. In the meantime, waste are stored in temporary facilities which when properly designed, as is the case generally in OECD countries, provide a safe and flexible interim solution. Currently, national efforts are concentrated on R&D activities, the safety and feasibility of various management alternatives, the selection of suitable disposal sites and optimisation studies covering safety, environmental, industrial and economical issues.

As there is in general little incentive for spent nuclear fuel and the high-level waste resulting from their reprocessing to be disposed of shortly after production, the development and implementation of disposal concepts can be envisaged in a step-wise or incremental basis. The most common elements of this approach consist of concept and technology development/demonstration; evaluation of site characteristics to enable a site specific facility to be designed; assessment of the long-term performance of a facility at a given site with a given design; construction and operation of the facility while site observation and performance assessment activities continue; completion of disposal operations and decommissioning of surface facilities; and eventually the sealing of all access shafts, tunnels and exploratory boreholes to place the facility in a passively safe state.

This step-wise or incremental approach provides ample opportunity for ongoing review and consideration of different management options for the short-, medium or even long-term. As a matter of fact, the progressive approach followed implies a number of milestones, with decisions taken in a relatively open and transparent context. National programmes and their schedules for the various steps are publicly available in most countries, all indicating that no long-lived radioactive waste will be disposed of without prior evidence of the safety of the concept and a series of successive decisions over a period of 20 to 40 years.

When deep geological repositories become available, their operation will last for a few decades, and then a decision will be needed to close the site. Until that stage, waste is more or less easily retrievable. Strictly speaking, the deep geological disposal concept does not rely on the need for interventions after a repository has been sealed, or on environmental monitoring measures to
assure long-term safety. However, such interventions are not necessarily to be excluded. In practice, even after a repository is sealed, retrieval of the waste would not be totally impossible, the difficulties increasing, however, with time. The technology required for such an operation could be developed on the basis of current knowledge. Technical difficulties and costs would vary considerably depending on the host rock characteristics, and on the design of the repository which may or may not facilitate such operations. Nevertheless, the option of going back to the waste and possibly retrieving it, whatever the reasons for this, would not be totally foreclosed.

Finally, another feature of geological disposal programmes is that they benefit from close international cooperation activities, including the exchange of information and experience on safety assessments and peer reviews by independent teams of experts. Such activities cover practically every aspect of radioactive waste management and lead to relatively homogeneous and consistent approaches around the world.

As a concluding remark for this section, it can be stated that the isolation of long-lived radioactive waste into deep geological systems, under passive conditions, seems to offer a safe and technically feasible solution specially designed to meet ethical and environmental concerns about benefits, liabilities and risks bequeathed to future generations. This is the central strategy of practically all countries with nuclear power programmes, with progressive implementation schedules giving ample time and flexibility for considered decisions to be taken before waste is actually disposed of. However, there still exist, mostly at the non-technical level, different perceptions and even scepticism about the soundness of the concept, with a diversity of value perspectives concerning the ethical and environmental background, showing the need for an in-depth reflection on those aspects. The next section tries to identify these issues.
IV. ENVIRONMENTAL AND ETHICAL ISSUES TO BE ADDRESSED AT THE WORKSHOP

In recent years, a number of national studies have been made to review the ethical basis of radioactive waste disposal, notably the long-term aspects. Some of the main conclusions are reproduced in Appendices 3 and 4. These studies have provided interesting views on ethical issues, but do not answer all the questions raised concerning the soundness of the geological disposal approach proposed by the nuclear community. Following a survey made among members of the RWMC to prepare the September 1994 workshop, many issues were listed again. They are summarized in this section, with a view to their being addressed by the speakers invited to the RWMC Workshop, together with any other questions the speakers would like to raise themselves. The objective of this procedure is to try to promote relatively pragmatic and focused reactions from the participants, since it is recognized that translating philosophical concepts based on ethical values into practice can be problematic.

1. One of the very first issues raised concerns the right of current generations to take decisions that are going to affect future generations, particularly when the benefits and the risks are not evenly distributed between the present and the future. The basic question can be phrased as follows: Can risk or responsibility for essential action be imposed (on future generations) when the benefits are perceived to be incurred by others (the current generations) and, if so, under what conditions?

In the case of nuclear electricity production, the application of radiation protection principles presupposes that there is a net positive benefit to current generations and no significant or unacceptable detriment to future generations. However, even assuming some benefits to mankind in the longer term as a result of sustained technological advancement leading to the continuing availability of sufficient energy sources, this risk/benefit issue does not seem to have been considered in a systematic way: for example through life cycle assessment of energy production alternatives considering sustainability of the energy source, emissions to the environment and the ultimate disposal of by-products and waste. (See later considerations on cost/benefit evaluation and distribution).

2. Another general question is the following: Do current generations have the right to take decisions today which would foreclose options of future generations? Two main aspects of this question are the following:

- Disposal solutions are designed to be permanent as long as their long-term safety has been clearly established. However, with the prospects for improved scientific knowledge and technology, other options might prove more satisfactory to future generations from a safety, economic, or other viewpoint. Part of this question which is connected to the retrievability of waste is covered later on in the document;

- In spite of all the current requirements for safety and siting of long-lived waste repositories, the use of some as yet unidentified environmental resources might be affected by the presence of radioactive waste substances in given areas restricting, therefore, the potential for their future exploitation.
3. A corollary question is: Could or should the responsibility for developing solutions to the radioactive waste problem be transmitted to future generations? Given the uncertainty of the stability of society, would future generations have the knowledge and resources necessary for the construction of appropriate repositories? Could the degree of endowment of resources specifically devoted to this problem affect that choice?

4. The concepts of sustainable development and intergenerational equity seem to have been precisely developed to answer some of the above questions about fairness between generations, particularly with regard to the far future. However, examples seem to be lacking where detailed practical application of these concepts would have led to clear conclusions about environmental or other societal issues likely to affect future generations. The question may be raised, therefore, as to whether these concepts could be applied in a practical way to address the optimum combination of responsibilities, options and resources to be bequeathed to future generations for the care of their health and environment.

5. In the radioactive waste disposal field, the intergenerational equity principle has been translated into the apparently simple and straightforward requirement that the safety level in the future be equivalent to that which is currently acceptable, irrespective of time, and without the necessity for active intervention by future generations.
   a. Does this approach represent an innovation, at least as far as a long-term safety provision concerned, and if so, why?
   b. Is it fair to postulate that contemporary safety norms should be the basis for the protection of future populations? Or is there another way to determine the degree of risk acceptable to future generations? Assuming that scientific and medical progress will take place, for example in cancer research, would it be possible to take such progress into account in assessing future risks?

6. Recognizing that everything we do in the present has some potential impact in the future, would it be correct to consider that the application of the sustainable development and intergenerational equity concepts requires that both benefits and risks passed on future generations be taken into account in deciding what is equitable and what is not?

7. Cost/benefit evaluations are usually complex and involve value judgements, notably when costs and benefits are not distributed homogeneously in time and space which is generally the case. Hence, a series of questions which it would be useful to discuss in an ethical context.
   a. Discounting of costs with time is a widely applied technique in the evaluation of the impact of economic and industrial decisions. Could or should discounting of long-term health risks due to radioactive waste disposal be envisaged?
   b. Is it possible to assess what is passed on to future generations in terms of health risks, other detriments and possible benefits of all sorts, directly or indirectly? Should such an assessment be applied generically to human activities in a broad sense or should it concern only waste disposal issues?
c. How can the immediate needs of the current generations, for instance for energy generation or public health protection, be balanced with intergenerational equity requirements in the very long-term? This question is addressed in further detail by the next ones.

d. Are resources devoted to assuring safety of radioactive waste disposal appropriately balanced with risks, given that these resources could be applied to other societal goals? This question directly relates to achieving an appropriate balance between securing the resources needed to meet current needs, on the one hand, and conserving resources and protecting the environment to meet the needs of future generations, on the other hand. It is also related to the question of "how safe is safe enough" in a given area, and to the management of other risks which need to be kept under control as well. Even for decisions related to our own activities in the present generation, individual and societal goals often conflict. Several approaches have been used in making risk decisions on acceptable risks, including margins of safety, consideration of cost/benefit, and comparison to other risk levels. These techniques have been increasingly questioned and decision-makers are considering alternative techniques, including negotiation and consensus building. Are there principles and decision-making processes which could be used to determine where resources should be applied?

e. Is it preferable to take all physical actions today to minimize any bequest of liabilities for waste management actions to future generations. If not, how should financial assets be set aside to meet the liabilities?

f. There is a need to balance the risks to which we expose the current generation (or the immediate next generations), risks that can more readily be identified and to a certain extent quantified, against the risks to which we may be exposing some very far distant future people, risks that are much more difficult to quantify. If we follow a given course of action today to reduce the risk to the future generations, we need to take into account the risks to which we are exposing the present generation, notably the workers involved. What guidelines and principles should we follow to balance these risks? Does the proposition that we should not expose future generations to a risk that is not acceptable today appropriately address this issue?

g. Should measures of risk acceptability be considered in the context of individual rights or local rights, or the collective rights of the population?

h. In relation to the previous questions, there is the additional issue of the distribution of environmental risks across population groups, called "environmental justice". All communities and individuals, regardless of economic status or race are entitled to a safe and healthful environment. What measures are necessary in the siting of repositories to assure that disadvantaged populations do not bear disproportionate burdens?

i. In this respect, is there an ethical basis for a "host" community to receive some form of compensation in recognition of the service that it is providing to society?
V. THE GEOLOGICAL DISPOSAL STRATEGY FOR LONG-LIVED
RADIOACTIVE WASTE AND ITS IMPLEMENTATION

In the light of the general questions raised above, which touch issues much broader than the
management of radioactive waste, it is desirable to consider more specifically how the geological
disposal strategy developed for long-lived radioactive waste fits within the general ethical and
environmental context. In particular, the definition of the long-term objectives and the progressive and
incremental character of this strategy, with “demonstration” of the long-term safety prior to the
implementation of disposal systems, are of particular importance.

1. Disposal objectives

In spite of the large degree of consensus on the formulation of disposal objectives and safety
requirements to be met to cover long-term obligations (see Appendices), these (or similar objectives)
do not seem to be considered for possible applications to other types of hazardous waste. It may be
appropriate to comment on this situation and raise the following questions:

a. Do the objectives of geological disposal, as defined currently and illustrated in
Appendix 1, take appropriately into account all the relevant ethical and environmental
protection requirements, as discussed above?

b. Are these objectives fair, or perhaps too ambitious, in requesting a level of safety for
the future equivalent to the one acceptable today, irrespective of time and without
remedial intervention?

c. Should discounting of future health effects be acceptable within a broad cost/benefit
approach of present and long-term societal issues? Would it be appropriate to
envisage the application of discounting to radioactive waste disposal, and, if so, under
which possible conditions and timescales? (See IV.7.b above).

2. Strategic decisions

The waste management philosophy is based on the disposal concept which is intended, by
definition, to be a final action, as opposed to interim storage situations, which are by definition only
intermediate solutions prior to disposal. As mentioned in Section III.4 of this document, until access
to a repository is closed, the waste is more or less easily retrievable. Some countries actually require
that retrievability should be foreseen for some period of time after waste emplacement, with conditions
similar to the ones typical of an interim storage situation. Such a requirement is in general limited in
time, for example during the few decades necessary to operate the site and decide whether or not it
should be sealed under the conditions foreseen. After closure of a disposal site interventions and
possible retrieval would not be required in principle and, usually, they are not foreseen in the design
of repositories. However, even under these difficult conditions, the technical feasibility of such
operations should not necessarily be ruled out.

The question of retrievability is currently under consideration in research and development
studies, taking into account the need to avoid interference with the passive safety of the repository in
the long-term, and the very remote possibility of an intervention shortly after closure. In this context,
the Dutch authorities have decided that long-term retrieval should be required for both long-lived
radioactive waste and highly toxic chemical waste (see Appendix V). The consequence of this decision
is to reject for the time being the concept of disposal in the Netherlands. This is not, however, the
attitude prevailing in most other countries and, given the sensitivity of this subject, it is appropriate to
address it, notably with the following questions: Is retrievability of waste important after closure of a

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repository? To what extent should it be facilitated by the design of the repository? Would the difficulties involved in retrieval of the waste justify postponing sealing of repository access and closure of the site, or even rejecting the concept of disposal, all safety considerations being taken into account?

The disposal concept may or may not involve measures of institutional control for limited time periods to maintain or enhance safety. It is designed to be a passive, self-maintained long-term safe solution, to be implemented by current generations to discharge their responsibilities vis-a-vis the future. This approach is to be implemented through a series of decisions and steps covering the development, construction, operation and eventually closure of deep geologic disposal systems taking place over a long time span - perhaps as many as a hundred years. In order to make progress towards the objectives, the involvement of our offspring, essentially during the next few generations, will be required. This is a relatively short-term commitment only, leaving to our immediate descendants the task to decide whether and when to close the repository. This does not seem to create major issues as long as this is properly planned and organised. The situation is not the same for the generations after, for example when the repository retains its integrity over thousands of years, or in the very long term (10,000-100,000 years) when some degree of dispersion of its radioactive content may occur. A series of questions may be raised in this context:

a. Does the fact that a final decision on the closure of a disposal site is left to our offspring, about a century from now, raise special concern? Could it be regarded rather as an advantage as ample time will be available for the decision to be taken, including consideration of a better scientific knowledge at the time?

b. Independently from safety considerations, would it be ethically appropriate for a given generation such as our own to postpone proceeding for some period of time and what would be the ethical basis to delay proceeding?

c. Is it preferable to proceed as indicated above and implement disposal plans such that no future intervention is going to be required?

d. What will be the appropriate balance to achieve in constructing a repository such that controls and corrective measures are unnecessary while allowing future generations the option to take advantage of advances in knowledge which may potentially increase safety? Many countries are pursuing a policy which requires a permanent solution to high-level waste disposal requiring that wastes will remain secure without reliance on active monitoring or controls. Wastes are to be disposed of in a manner such that future generations will not be required to take unusual measures to protect themselves or their environment. A question arises as to whether future generations should by design be left the option to correct any mistakes that we may make in waste disposal, taking advantage of advancements in knowledge. (This question is, to some extent, linked to waste retrievability).

e. The "Polluter Pays Principle" is largely implemented in the context of national radioactive waste disposal programmes, and many countries have raised funds for disposal programme costs. However, the fees collected on the basis of the amount of electricity produced are based on estimates and take into account the time value of money. Is this an ethically sound approach and is there a need to go beyond for the time being?

f. Are there ethical issues associated with the concept of an international waste repository serving the need of several countries, on the assumption that all safety, technical and economical conditions are satisfactory?
As most countries are already making plans for the implementation of a geological disposal strategy for their long-lived radioactive waste, it would be desirable to examine, at both national and international levels, whether or not this is a sound approach, all technical and non-technical issues being considered: After a review of the relevant ethical and environmental aspects involved, is it possible to conclude that the geological disposal strategy is in principle appropriate and compatible with the long-term requirements for the protection of future generations and their environment? Or, alternatively, in the context of our developing world and the need for a sustainable development approach, is there any fundamental ethical or environmental consideration which would disqualify this strategy? In addition to being addressed at the concluding session of the Workshop, these questions will be examined by the RWMC at its next meeting in 1995, and be the subject of its next Collective Opinion.
101. Research and development in the field of nuclear science and technology have been ongoing since the beginning of the twentieth century leading to wide-scale applications in research, medicine, industry and in the generation of electricity by nuclear fission. In common with other human activities, these practices generate waste that requires management to ensure the protection of human health and the environment now and in the future, without imposing undue burdens on future generations. Radioactive waste may also result from the processing of raw materials that contain naturally occurring radionuclides. To achieve the objectives of safe radioactive waste management requires an effective and systematic approach within a legal framework within each country in which the roles and responsibilities of all relevant parties are defined.

102. Radioactive waste occurs in a variety of forms with a wide range of physical and chemical characteristics, such as concentrations and half-lives of radionuclides. This waste may occur

- in gaseous form, such as ventilation exhausts from facilities handling radioactive materials;

- in liquid form, ranging from scintillation liquids from research facilities to high level liquid waste from reprocessing of spent fuel; or

- in solid form, ranging from contaminated trash and glassware from hospitals, medical research facilities and radiopharmaceutical laboratories to vitrified reprocessing waste or spent fuel from nuclear power plants when it is considered a waste.

The radioactivity in such wastes may range from very low levels, as in those generated in medical diagnostic procedures, to very high levels as in vitrified reprocessing waste or in spent radiation sources used in radiography, radiotherapy or other applications. Radioactive waste may be very small in volume, such as a spent sealed radiation source, or very large and
diffuse, such as tailings from mining and milling of uranium ores and waste from environmental restoration. Basic principles for radioactive waste management have been developed even though there are large differences in origin and characteristics of radioactive waste, for example, concentration, volume, half-life and radiotoxicity. Although the principles are generally applicable their implementation will vary depending on the types of radioactive waste and their associated facilities.

103. Radioactive waste, as a source of ionizing radiation, has long been recognized as a potential hazard to human health. Therefore, national regulations and internationally recommended standards and guidelines dealing with radiation protection and radioactive waste management have been developed, based on a substantial body of scientific knowledge. It has also been an exemplary feature of radioactive waste management that special attention has been given to protection of future generations. Considerations related to future generations may include potential radiation exposure, economic consequences and the possible need for surveillance or maintenance.

104. Radioactive waste may also contain chemically or biologically hazardous substances and it is important that hazards associated with these substances are adequately considered in radioactive waste management.

105. International experience with these various radioactive wastes has resulted in the evolution of fundamental safety approaches for the management of radioactive waste. The IAEA, in its Radioactive Waste Safety Standards (RADWASS) series of documents, integrates this experience into a coherent set of principles, standards, guides and practices for achieving safe radioactive waste management.

**OBJECTIVE**

106. This document defines the objective and the associated set of internationally agreed principles for the management of radioactive waste. These principles are a common basis for the development of more detailed IAEA Safety Standards, Safety Guides and Safety Practices under the RADWASS programme and provide a basis for the radioactive waste management programme in individual Member States.
SCOPE

107. This document presents radioactive waste management principles that apply to radioactive material, as determined to be radioactive waste by the appropriate national authorities, and to the facilities used for the management of this waste from generation through disposal. These principles apply to all aspects of radioactive waste management except where an activity is the specific subject of an IAEA document outside the RADWASS series or an international instrument, for example, the transportation of nuclear material and exports and imports of nuclear material. They also apply when managing radioactive waste containing, for example, chemically or biologically hazardous substances even though other specific requirements may be applicable.

STRUCTURE

108. The Safety Fundamentals include the objective of radioactive waste management (Section 2) and fundamental principles of radioactive waste management (Section 3). The fundamental principles fall into the following general subject areas: protection of human health, protection of the environment, protection beyond national borders, responsibility to future generations and implementation procedures. Each principle is stated, and supporting and explanatory information pertaining to the principle is provided. The sequence in which the principles are presented does not necessarily reflect any order of priority.

109. The Annex describes the basic steps in radioactive waste management to provide a common understanding among users of RADWASS documents. The document also contains a glossary of terms used in this document.

2. OBJECTIVE OF RADIOACTIVE WASTE MANAGEMENT

201. The objective of radioactive waste management is to deal with radioactive waste in a manner that protects human health and the environment now and in the future without imposing undue burdens on future generations.
3. FUNDAMENTAL PRINCIPLES OF RADIOACTIVE WASTE MANAGEMENT

301. Responsible radioactive waste management requires the implementation of measures that will afford protection of human health and the environment since improperly managed radioactive waste could result in adverse effects to human health or the environment now and in the future.

302. The timely creation of an effective legal framework and an organizational infrastructure within each Member State provides the basis for appropriate management of radioactive waste. The individual steps in radioactive waste management as outlined in the Annex may be dependent on each other, and thus require co-ordination. Taking this interdependence into account will help to ensure safety in all radioactive waste management steps.

303. The fundamental principles enunciated for radioactive waste management will, if implemented and respected, ensure that the above considerations are addressed, and thus allow the achievement of the objective of radioactive waste management. The principles and their supporting text should be considered as an entity. They are presented in the following text of this document.

**Principle 1: Protection of human health**

Radioactive waste shall be managed in a way to secure an acceptable level of protection for human health.

304. Many of the hazards induced by radioactive waste are similar to those associated with toxic waste from, for example, mining and chemical plant operations and should be controlled. However, the nature of the radioactive waste implies another hazard, namely the possibility of exposure to ionizing radiation. An acceptable level of protection therefore needs to be provided. Particular attention needs to be paid to control the various ways by which humans might be exposed to radiation, and to ensure that such exposure is within established national requirements.
Member States establish their radiation protection requirements for broader purposes than radioactive waste management. When establishing acceptable levels of protection, Member States typically take account of, among other things, the recommendations of the International Commission on Radiological Protection (ICRP) and the IAEA and specifically the concepts of justification, optimization and dose limitation. The relevance of these concepts depends on the type of radioactive waste management activities.

Radioactive waste management activities occur either associated with a practice, for example, nuclear power generation, or associated with an intervention, for example, following an accident. In the case of a practice, radioactive waste management should be taken into account in the justification of the entire practice giving rise to the radioactive waste, and therefore need not be justified in itself. Optimization and dose limitation remain applicable. In the case of an intervention, justification and optimization are required, but not the concept of dose limitation.

Human activities and their consequences may be separated by long time periods, for example, in the case of radioactive waste disposal. In such cases, in planning for safe radioactive waste management, Member States should consider the facts that the benefits and the exposures might affect populations separated by many generations, that long time periods lead to increased uncertainties in the results of safety assessments and that radionuclides decay.

**Principle 2: Protection of the environment**

Radioactive waste shall be managed in a way that provides an acceptable level of protection of the environment.

When radionuclides are released into the environment, species other than humans can potentially be exposed to ionizing radiation, and the impacts of such exposures should be taken into consideration. Since humans are among the most radiation-sensitive organisms, however, their presence should generally be assumed when assessing impacts on the environment, particularly when assessing impacts of radioactive waste disposal.
309. Radioactive waste disposal may have local adverse effects on the future availability or utilization of natural resources, for example, land, forests, surface waters, ground waters and raw materials, over extended periods of time. Radioactive waste management, therefore, should be conducted in such a way as to limit, to the extent practicable, these effects.

310. Radioactive waste management activities may result in non-radiological environmental impacts, such as chemical pollution or alteration of natural habitats. These impacts need to be considered and radioactive waste management undertaken with a level of environmental protection at least as good as that required of similar industrial activities.

Principle 3: Protection beyond national borders

Radioactive waste shall be managed in such a way as to assure that possible effects on human health and the environment beyond national borders will be taken into account.

311. This principle is derived from an ethical concern for human health and the environment in other countries. It is based on the premise that a country has a duty to act responsibly and not to impose effects on other countries greater than those which have been judged acceptable within its own borders taking into account recommendations of international bodies such as ICRP and IAEA.

312. In the case of normal release, potential release or migration of radionuclides across national borders, the country of origin could choose to find agreement regarding elaboration of this principle, for example, through exchange of information or arrangements with neighbours or affected countries.

313. Import and export of radioactive waste is the subject of the IAEA "Code of Practice on the International Transboundary Movement of Radioactive Waste", which states in part that a state should receive radioactive waste for management or disposal only if it "has the administrative and technical capacity and regulatory structure to manage and dispose of such waste in a manner consistent with international safety standards".

1) refers to effects on individuals.
Principle 4: Protection of future generations

Radioactive waste shall be managed in a way that predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today.

314. This principle is derived from an ethical concern for the health of future generations. When establishing acceptable levels of protection, Member States typically take account of, among other things, the latest recommendations of international organizations, for example, the ICRP and the IAEA.

315. While it is not possible to ensure total isolation of radioactive waste over extended time scales, the intent is to achieve reasonable assurance that there will be no unacceptable impacts\(^1\) on human health. This is typically achieved by applying the multibarrier approach in which both natural and engineered barriers are utilized. The existence of suitable natural barriers is usually determined within a siting process. Furthermore, account should be taken of possible future exploration for, or exploitation of, valuable natural resources that could potentially result in adverse effects on the isolation capability of a disposal facility. In implementing radioactive waste management, particularly for disposal, uncertainties in long term safety assessment, due to the inherent difficulty in predicting impacts far into the future, should be taken into account.

Principle 5: Burdens on future generations

Radioactive waste shall be managed in a way that will not impose undue burdens on future generations.

316. Consideration for future generations is of fundamental importance regarding the management of radioactive waste. This principle is based on the ethical consideration that the generations that receive the benefits of a practice should bear the responsibility to manage

\(^1\) refers to impacts on individuals
the resulting waste. Limited activities, however, may be passed to succeeding generations, for example, the continuation of institutional control, if needed, over a disposal facility.

317. The responsibility of the present generation includes developing the technology, constructing and operating facilities, and providing a funding system, sufficient controls and plans for the management of radioactive waste.

318. The timing and implementation of disposal of individual radioactive waste types will depend on scientific, technical, social and economic factors such as the availability, acceptability and development of suitable sites and the decrease of radioactivity levels and heat generation during interim storage.

319. Management of radioactive waste should, to the extent possible, not rely on long term institutional arrangements or actions as a necessary safety feature, although future generations may decide to utilize such arrangements, for example, to monitor radioactive waste repositories or retrieve radioactive waste after closure has been effected. The identity, location and inventory of a radioactive waste disposal facility should be appropriately recorded and maintained.

Principle 6: National legal framework

Radioactive waste shall be managed within an appropriate national legal framework including clear allocation of responsibilities and provision for independent regulatory functions.

320. Countries in which radionuclides are being produced or used should develop a national legal framework, taking into account overall national radioactive waste management strategies, and providing laws, guidelines and regulations for radioactive waste management. The responsibilities of each party or organization involved should be clearly allocated for all radioactive waste management activities that take place in a country.

321. Separation of the regulatory function, including enforcement, from the operating function is required to ensure safe operation of nuclear facilities. This separation will achieve
independent review and overseeing of radioactive waste management activities. The legal framework should specify the way in which separation of the functions is achieved.

322. Since radioactive waste management can span time-scales involving a number of human generations, appropriate consideration of present and likely future operations should be taken into account. Provisions for sufficiently long lasting continuity of responsibilities and funding requirements should be made.

Principle 7: Control of radioactive waste generation

Generation of radioactive waste shall be kept to the minimum practicable.

323. The generation of radioactive waste shall be kept to the minimum practicable, both in radioactivity and volume, by appropriate design measures and operating practices. This includes the selection and control of materials, the recycle and reuse of materials, and the implementation of appropriate operating procedures. Emphasis should be on segregation of different types of waste and materials to reduce the volume of radioactive waste and facilitate its management.

324. Safe radioactive waste management includes keeping the releases from the various waste management steps to the minimum practicable. The preferred approach to radioactive waste management is concentration and containment of radionuclides rather than dilution and dispersion in the environment. However, as part of radioactive waste management, radioactive substances may be released within authorized limits as a legitimate practice through air, water, soil and residues and also through the reuse of materials. Appropriate safety and control measures should be defined.

Principle 8: Radioactive waste generation and management interdependencies

Interdependencies among all steps in radioactive waste generation and management shall be appropriately taken into account.
Basic steps in radioactive waste management, depending on the type of waste, are pretreatment, treatment, conditioning, storage and disposal (see Annex). There are interdependencies among and between steps in waste management. Decisions on radioactive waste management made at one step may foreclose alternatives for or otherwise affect a subsequent step. Further, there are relationships between waste management steps and operations that generate radioactive waste or materials that can be recycled or reused. It is desirable that those responsible for a particular waste management step or operation generating waste adequately recognize interactions and relationships so that, overall, safety and effectiveness of radioactive waste management are balanced. This includes taking into account identification of waste streams, characterization of waste and the implications of transporting radioactive waste. Conflicting requirements that could compromise operational and long term safety should be avoided.

Since the steps of radioactive waste management occur at different times, there are, in practice, many situations where decisions must be made before all radioactive waste management activities are established. As far as reasonably possible, the effects of future radioactive waste management activities, particularly disposal, should be taken into account at the time of considering any one radioactive waste management activity.

**Principle 9: Safety of facilities**

Safety of facilities for radioactive waste management shall be appropriately assured during their lifetime.

Siting, design, construction, operation and decommissioning of a facility or closure of a repository should be carried out giving safety matters priority. This includes prevention of accidents and limitation of consequences should accidents occur. Throughout these steps, Member States typically take account of public issues.

Site selection should take into account relevant features which might affect the safety of the facility or which might be affected by the facility.
329. Design, construction, operation and activities during decommissioning of a facility or closure of a repository should provide and maintain, where applicable, an adequate level of protection to limit possible radiological impacts.

330. Application of the appropriate level of quality assurance and of adequate personnel training and qualification should be addressed throughout the life of radioactive waste management facilities.

331. Appropriate assessments should be performed to evaluate the safety and the environmental impacts of the facilities.
BIBLIOGRAPHY


APPENDIX 2

DISPOSAL OF RADIOACTIVE WASTE

CAN LONG-TERM SAFETY BE EVALUATED?

An international Collective Opinion

Published by OECD in 1991
EXECUTIVE SUMMARY

Radioactive waste disposal systems are designed to isolate the waste from humans and the environment for the necessary times to ensure that no potential future releases of radioactive substances to the environment would constitute an unacceptable risk. Such systems have been built at or near the surface for low-level and short-lived wastes, and are widely envisaged to be built deep underground in geological formations for high-level and long-lived wastes.

The long-term safety of any hazardous waste disposal system must be convincingly shown prior to its implementation. For radioactive wastes, safety assessments over timescales far beyond the normal horizon of social and technical planning have already been conducted in many countries. These assessments provide the principal means to investigate, quantify, and explain long-term safety of each selected disposal concept and site for the appropriate authorities and the public. Such assessments are based on four main elements: definition of the disposal system and its environment, identification of possible processes and events that may affect the integrity of the disposal system, quantification of the radiological impact by predictive modelling, and description of associated uncertainties.

The NEA Radioactive Waste Management Committee and the IAEA International Radioactive Waste Management Advisory Committee have carefully examined the current scientific methods for safety assessments of radioactive waste disposal systems, as briefly summarised in this report. The Committees have also reviewed the experience now available from using safety assessment methods in many countries, for different disposal concepts and formations, and in the framework of both nationally and internationally conducted studies, as referenced in this report.

Following this review, the NEA Radioactive Waste Management Committee and the IAEA International Radioactive Waste Management Advisory Committee

- Recognise that a correct and sufficient understanding of proposed disposal systems is a basic prerequisite for conducting meaningful safety assessments,
- Note that the collection and evaluation of data from proposed disposal sites are the major tasks on which further progress is needed,
• Acknowledge that significant progress in the ability to conduct safety assessment has been made,

• Acknowledge that quantitative safety assessments will always be complemented by qualitative evidence, and

• Note that safety assessment methods can and will be further developed as a result of ongoing research work.

Keeping these considerations in mind, the two Committees

• Confirm that safety assessment methods are available today to evaluate adequately the potential long-term radiological impacts of a carefully designed radioactive waste disposal system on humans and the environment, and

• Consider that appropriate use of safety assessment methods, coupled with sufficient information from proposed disposal sites, can provide the technical basis to decide whether specific disposal systems would offer to society a satisfactory level of safety for both current and future generations.

This Collective Opinion is endorsed by the CEC Experts for the Community Plan of Action in the Field of Radioactive Waste Management.
THE NEED TO EVALUATE LONG-TERM SAFETY

More than ten years have passed since the first comprehensive long-term safety assessments of well-defined radioactive waste disposal systems appeared. Large resources are being devoted to disposal system development, site investigation studies, and safety assessments. For low-level and short-lived wastes, there already exist operating disposal systems in some countries, with new repositories planned or under construction in others. For high-level and long-lived wastes, the process of licensing and implementation for repositories has started in some countries, although the first high-level waste repositories are not expected to begin operation until about twenty years from now.

The practical objective of any radioactive waste disposal system is isolation of the wastes from humans and the environment for the necessary times to ensure that no potential future releases of radioactive substances to the environment would constitute an unacceptable risk. In the planning and implementation of projects for final disposal, two basic premises have been stressed. First, the potential radiological long-term hazard is explicitly acknowledged and the responsibility of ensuring that future generations are protected at a level at least equal to that considered acceptable for ourselves is openly accepted. Second, as a direct consequence of this commitment, it is recognised that the long-term safety of the solution offered must be convincingly shown prior to disposal.

These issues were first addressed by the NEA Radioactive Waste Management Committee in a 1985 report. In particular, with regard to the disposal of long-lived radioactive wastes, the Committee expressed the views that deep geological disposal with a passive system of containment barriers is a feasible approach that could provide adequate safety, and that such disposal should eventually replace storage requiring continued maintenance and surveillance by society.

But what of the second issue, that of showing safety? In radioactive waste management, attempts have been made to analyse the safety of disposal over timescales far beyond the normal horizon of social and technical planning. Debate has arisen, however, on the feasibility of such analyses, and scepticism is often encountered about the validity of their results. In particular, three important questions arise:
• Can the behaviour of the disposal system and its potential radiological impacts on humans and the environment be sufficiently well understood over many thousands of years (for high-level and long-lived wastes), or even over hundreds of years (for low-level and short-lived wastes)?

• Can specialists and the competent authorities be convinced that the predicted behaviour is representative of what might actually happen?

• Can the potential radiological impacts and the means of estimating these impacts be illustrated transparently for a wider audience?

The need to develop capabilities to respond to these questions has stimulated the growth of the discipline of safety assessment over the past fifteen or so years. The objective of this document is to distill into a concise and easily accessible form the consensus that has emerged on the approach and practical methods for assessing the safety of radioactive waste disposal. This objective is achieved in what follows in three ways:

• By pointing out major overall issues on which wide international consensus has been attained;

• By explaining how the quantitative results of long-term safety assessments are generally interpreted;

• By discussing briefly several key issues influencing the acceptability of assessment results.
POINTS OF CONSENSUS

Safety assessment can be defined as an analysis of the future behaviour of the overall waste disposal system and of its potential impacts on humans and the environment, followed by comparison of the results with appropriate safety standards. Over the years, increasing international consensus has been reached on the role of and framework for safety assessment. Three aspects in particular of this consensus can be stressed:

- First, it is recognised that the future behaviour of the disposal system must be understood well enough to assure that no harmful releases of radioactive substances to the environment are likely to occur, even if it is not considered necessary (or possible) to predict this behaviour in every detail. Safety assessments in the broad sense provide the principal means to gain this understanding and to convey it to responsible authorities and the interested public,

- Second, wide international consensus exists regarding the general approach for safety assessments (see Annex 1 for details), as well as the procedures for obtaining data, developing and using models, and performing and reviewing safety assessments. It is clearly understood that safety assessments require effective use of predictive modelling methods and a wide range of scientific information that describes the disposal system and its possible evolution.

- Third, it is recognised that safety assessments must form an integral part of repository development programmes at an early stage of research, and throughout the course of siting, design, construction, operation, and decommissioning and final sealing of radioactive waste disposal systems. Prior to licensing a particular site and repository design, safety assessments must proceed iteratively with disposal system siting and development, to determine if further information is needed and, if so, what type of information is needed. Safety assessments form a crucial part of the licensing documentation for disposal systems.
WHAT CAN BE EXPECTED FROM SAFETY ASSESSMENTS

Absolute proof of continuing safe behaviour is impossible for all technical systems, including radioactive waste disposal systems. What must be achieved is a convincing and indirect demonstration that the proposed disposal system provides a sufficient level of safety to both current and future generations. Accordingly, what is expected and sought is a scientific and regulatory process that properly considers those factors that might significantly affect safety, and in that way provides the basis to decide if the proposed waste disposal system can be considered safe enough in the long term.

For this purpose, calculations are performed to estimate potential releases of radionuclides from the waste repository, and the possible radiation dose consequences of these releases for individuals assumed to be living near the site at some time in the future. Two important observations can be made concerning these calculations:

- Releases of radionuclides from a waste repository are postulated to occur under expected circumstances involving the gradual degradation of the safety barriers of the system, and under less likely circumstances involving a disruption to the series of safety barriers. Consequences must, therefore, be seen in the light of how severe they may be and how likely they are to occur, in order to assess the actual risks.

- Calculations of doses resulting from releases of radioactivity into the environment several thousands of years or more from now are generally based on current living habits. Any estimate of far future living conditions would be largely speculative. Such calculations are, therefore, generally viewed as an illustration of what the doses would be if the release occurred today, rather than as a prediction of the actual dose to some human living in the far future.

Thus, the assessed long-term radiological consequences of disposal systems are normally considered as indicators of safety that can be compared to safety standards.
JUDGING SAFETY

The current state-of-the-art in safety assessment methods is briefly summarised in Annex 1 of this report. There are, however, three topical issues that deserve to be highlighted here:

- The need for integrated assessments,
- The consideration of uncertainties in assessment results, and
- The methods for building confidence in assessment results.

The ultimate goal of assessments of repository behaviour is to determine possible radiological consequences to humans and the environment through an *integrated and systematic approach*. Such an assessment describes the characteristics of a specific disposal system, discusses the important aspects of the expected and predicted long-term evolution, and quantifies - to the extent possible - the impacts of the overall system in terms of radiological risks. All factors that might significantly affect safety are rigorously considered and clearly documented. Some phenomena taken into account in the course of the assessment may prove to be more or less important to the final results, as shown by *sensitivity analyses*. Emphasis is, therefore, placed on the coherent analysis and integration of all relevant safety elements.

*Uncertainties* are and will always be associated with assessment results. Some uncertainties may be quantifiable - for example, those that reflect the variability inherent in natural systems. Other uncertainties, however, may not be quantifiable in the same way - for example, those inherent in predicting certain future events that may disrupt the integrity of the disposal system. Formal use of expert judgement may be required to provide bounds on uncertainties, particularly for the latter type of uncertainty. An important aim of site characterisation and research concerns understanding of uncertainties and, whenever possible, quantification of these uncertainties, so as to be able to reduce the overall uncertainty in the results of integrated assessments. In this way, a sufficient basis for decisions may be provided.

The treatment of uncertainties in safety assessments is, however, part of a wider issue: the necessity of *building confidence* in disposal system safety. Confidence is achieved by many means. For example, confidence is enhanced through the
establishment of appropriate quality assurance and quality control procedures for conducting safety assessments, as well as for the supporting research and site investigations. Confidence is also built through the process of assuring (or validating) that the predictive models used in safety assessments adequately represent the behaviour of the real system. It is impossible to compare directly predicted behaviour with actual behaviour of the disposal system over the long periods for which safety must be shown. To obtain such assurance indirectly requires a systematic evaluation of modelling results against data from experiments in laboratories and in the field, as well as against data from studies of representative natural analogues, such as uranium deposits. Finally, expert judgement and peer review are also part of the confidence-building process. All of these activities, often conducted at international level, will need to be further supported in order to contribute to the enhanced credibility of assessment results.

The safety of a waste disposal system is judged, therefore, only after a clear presentation of the information obtained in an integrated assessment, after due consideration of the uncertainties associated with assessment results, and after a critical review by the competent regulatory authorities and others legally involved in the process. National regulatory systems include such requirements.
CONCLUSIONS : THE INTERNATIONAL VIEW

International co-operation - through information exchange and joint projects - plays a substantial role in the development of methods for safety assessment. In particular, international co-operation promotes periodic and systematic reviews of the state-of-the-art in this field, and contributes to informed and objective debate among specialists.

Following such a review, the NEA Radioactive Waste Management Committee and the IAEA International Radioactive Waste Management Advisory Committee

- **Recognise** that a correct and sufficient understanding of proposed disposal systems is a basic prerequisite for conducting meaningful safety assessments,

- **Note** that the collection and evaluation of data from proposed disposal sites are the major tasks on which further progress is needed,

- **Acknowledge** that significant progress in the ability to conduct safety assessment has been made,

- **Acknowledge** that quantitative safety assessments will always be complemented by qualitative evidence, and

- **Note** that safety assessment methods can and will be further developed as a result of ongoing research work.

Keeping these considerations in mind, the two Committees

- **Confirm** that safety assessment methods are available today to evaluate adequately the potential long-term radiological impacts of a carefully designed radioactive waste disposal system on humans and the environment, and

- **Consider** that appropriate use of safety assessment methods, coupled with sufficient information from proposed disposal sites, can provide the technical basis to decide whether specific disposal systems would offer to society a satisfactory level of safety for both current and future generations.

This Collective Opinion is **endorsed** by the CEC Experts for the Community Plan of Action in the Field of Radioactive Waste Management.
Annex 1

SUMMARY OF THE STATE-OF-THE-ART IN SAFETY ASSESSMENT METHODS

General Approach

The general approach to safety assessment consists of a number of interrelated elements:

- Broad identification of the possible future evolution of the selected disposal system (scenario development);
- Development and application of appropriate models;
- Evaluation of potential radiological consequences in an integrated assessment;
- Uncertainty and sensitivity analyses;
- Validation and review of all components of the assessment;
- Comparison of results with criteria;
- Documentation of the assessment.

Feedback between these elements and iteration through the full set of elements are important aspects of safety assessment.

Although wide international consensus exists on this general approach, it is important to note that different specific techniques are being used depending upon the purpose of an assessment and the type of safety criteria to be met. In addition, the models and data being used for safety assessment differ depending upon waste-specific, concept-specific, and site-specific conditions. Finally, identification and characterisation of the wastes to be disposed of, and of the disposal system as a whole, are necessary bases for meaningful safety assessment.
Scenario Development

Scenario development, the starting point for safety assessments, is concerned with defining the broad range of possible futures to be considered in the subsequent modelling and consequence calculations. Human imagination and scientific judgement coupled with existing knowledge of natural systems and man-made barriers form the basis of scenario development. Over the last few years, scenario development methods have been substantially improved by the use of approaches that are systematic and transparent. Extensive lists of phenomena (for example, faulting and seismicity, or erosion) that have to be initially considered in safety assessments have now been developed in many studies, and only a few new phenomena have been identified as potentially important in recent years, and these on a site-specific or concept-specific basis.

One particular area that has received greater attention recently is assessment of human intrusion scenarios. Work on the basic approach for consideration of human intrusion, and on the preservation of information about the site and the content of the repository is being undertaken.

If required by regulation or otherwise undertaken, the estimation of likelihood of occurrence of the final set of scenarios chosen for detailed consequence analyses can be a particularly difficult element of safety assessments. Although several different techniques are used, depending on the type of future events and processes being considered and the data available, all of them rely at least to some extent (and some quite heavily) on the use of expert judgement.

Model Development and Application

The necessity of using predictive models to assess potential radiological consequences in safety assessments is well recognised, and the general procedures for development of models are well accepted. The most important modelling areas were identified a long time ago, and predictive models have been developed in these areas. Substantial improvements toward more realism and detail have been made over the years. There are models available, at different levels of detail and realism, to evaluate and quantify the effects of the key processes determining the performance of radioactive waste disposal systems. Further development is still justified in some areas because better modelling could clarify or reduce uncertainties associated with assessment results. It could also contribute to further improvements in disposal system design.

In recent years, special attention has been given to the interdependence between model development and corresponding data gathering efforts. In addition, a main area of ongoing work is the coupling of models for specific processes into larger integrated
models and the simplifications needed to make them practical tools for safety assessments.

A sound basic understanding of the relevant physical and chemical properties of the system’s constituents and their evolution remains a main prerequisite for successful modelling.

**Integrated Assessments**

The ultimate goal of data gathering, scenario development, and predictive modelling is an integrated assessment describing the characteristics of the disposal system and quantifying the performance of the overall system in terms of radiological safety as a function of time. Many integrated assessments of both real and conceptual repositories in various host formations have been made over the years, indicating that it is possible to site and build repositories that can be considered safe for humans and the environment today and in the future (see the CEC/IAEA/NEA Symposium Proceedings for further details and references).

Safety assessment models tend to be of two complementary types: detailed research models and simplified system models. The detailed research models and their results are needed to evaluate design and engineering options, and are used to provide a defensible basis for excluding processes not important to safety in the more robust and simplified modelling. In the robust bounding approach, scenarios, models, and parameter values are chosen conservatively (that is, pessimistically). Thereby, the assessments are simplified and discussion of some uncertainties not significant to system safety are avoided in the licensing procedure.

**Uncertainty and Sensitivity Analysis**

Uncertainties are and will always be associated with assessment results. Uncertainties can partly be reduced by further model development and by collecting additional and more accurate data, but they can never be completely eliminated because they reflect a genuine variability in natural systems. Statistical methods are being increasingly relied on when extensive measurements of the needed data are unfeasible. Uncertainties sometimes also arise from a limited understanding of controlling processes.

As part of integrated safety assessments, sensitivity studies provide guidance on which areas uncertainties most need to be reduced. This guidance is specific with regard to disposal site and concept, and is being used to direct national resources for research and development to areas where they are most needed. In addition, the information on uncertainties is being provided to those responsible for repository design, enabling possible improvements to the design and siting of the repository.
The ultimate objective of safety assessments is to provide a basis for well-founded decisions about radioactive waste disposal systems. To this end, it is necessary that scientists, safety assessors, regulators, and those involved in or concerned with the decision-making process have confidence in the information, insights, and results provided by safety assessments. The importance of this topic is reflected in the main text, and only a few additional remarks concerning model validation are given here.

Model validation is the process of assuring that the models used adequately represent the real system behaviour, and efforts have been intensified during recent years in this area. Validation of long-term predictions must focus on the adequacy of modelling the processes that may define system performance under a reasonable variety of possible futures. There is no way to validate system performance predictions over long times, but the adequacy of specific aspects of the modelling may be supported through a variety of laboratory, field, and natural analogue studies. Several international co-operative projects have been established to investigate the possibilities for validation of the models used within safety assessments.

Validation needs depend upon the disposal concept. For some concepts, satisfactory validation can be done only with the help of in-situ studies at the potential disposal site. Increasing co-operation is apparent between those designing the repository and the relevant engineered barriers, and those studying the possibility of validating the models to be used in assessing the safety of the disposal system.

Regulatory Criteria for Disposal

In a final licensing assessment, the results of safety assessments are evaluated in the context of the established regulatory standards and criteria. International criteria for the radiological protection of individuals and populations have been used as the basis for development of national long-term safety criteria for radioactive waste disposal systems in practically all countries. Some countries currently have detailed regulations in place for radioactive waste disposal, whereas others have specified general radiological protection objectives, without necessarily as yet having established specific requirements for final disposal of wastes. Both on a national and an international basis, further work is underway to develop specific criteria for the long-term safety of radioactive waste disposal systems, in particular in order to have such criteria available in due course for the licensing of high-level waste repositories.

The details of safety assessment approaches, methods, and data requirements are dependent upon and influenced by the detailed criteria applied. Yet even where the detailed formulation of specific safety standards may differ between countries for legal
or historical reasons, it is evident that the same general type of safety assessment work is needed and is undertaken at some stage of the regulatory process.

**Documentation of Assessments**

The capability to make relatively detailed assessments has increased rapidly with the advance in models, and with the growing capacities of computers and data base systems. It is recognised, however, that clear presentation of the information obtained in an integrated assessment is an increasingly important and challenging task as ever more advanced and complex technical methods are developed. Work is ongoing in this area.
Annex 2

BIBLIOGRAPHY


APPENDIX 3

ETHICAL ASPECTS ON NUCLEAR WASTE

SOME SALIENT POINTS Discussed AT A Seminar On ETHICAL ACTION IN THE FACE OF UNCERTAINTY

Stockholm, Sweden, September 8-9, 1987

SKN REPORT 29
April 1988
6.6. Our Responsibility - The Responsibility of Coming Generations - The Need for Controls

One of the central questions posed at the seminar concerned our generation's responsibility to coming generations. According to the dominating view held thus far, it is our generation's responsibility to find a solution to the problem of nuclear waste that allows it, once it is disposed of, to remain secure without surveillance. KASAM has already questioned this idea in a previous report, mentioning that: "we lack the fundamental knowledge to take responsibility for every imaginable consequence to future generations and the basis of their existence", and that, according to a humanistic world-view, "it is of great worth that we guarantee coming generations the same right to integrity, ethical freedom and responsibility that we ourselves enjoy".

The seminar examined this extremely important question in depth and agreed unanimously that we are, in any case, on the way toward a necessary shift in the paradigms of our way of understanding. It remains, now, to plumb the consequences this will have for, among other things, the technical work involved in disposing of nuclear waste.

Basically two lines of reasoning were presented, both of which led, in principle, to the same conclusion. For the sake of clarity, we shall outline both.

According to the first and more detailed of the two, it is natural to demand two things from any technical product that is meant to be in use for a longer period: it must be safe in operation and, furthermore, repairable. The same qualities can be demanded of a nuclear waste repository. Safety in operation means, in this case, that the waste can be disposed of so that as far as we can predict, coming generations will not be obliged to take measures to protect themselves or their environment from it. Reparability means that coming generations can repair any mistakes we may have made in disposing of the waste.

Thus far safety in operation has been, almost without exception, the central theme of all discussion, research and political decisions regarding nuclear waste. This is the case, of course, because all debate on nuclear waste has arisen from the perspective of nuclear power. We have discussed the disposal of nuclear waste as a problem which can or cannot be solved as an argument for or against nuclear power. From that perspective, it makes sense to concentrate on the demand for safety in operation; thus, the reparability issue has remained in the background.

If, however, we proceed from the perspective of waste, i.e. putting emphasis on what we shall do with the considerable quantities of waste that must be dealt with, regardless of how we proceed with nuclear power, the need for reparability becomes far more urgent. From this perspective we are forced to take into consideration factors like the difficulty of getting different experts to agree completely on whether or not various systems can be considered absolutely safe without the possibility of getting inside to repair them, not to speak of the human errors and incorrect calculations that can also occur in the construction of a final repository.

It was pointed out that from this aspect, it is difficult to see how we can decide on a method of final disposal which is "irreversible", irrevocable, in the sense that the need for reparability is not met to any reasonable extent. Then too, it also becomes clear that the demands for safety in operation and reparability are, in part, in conflict with each other. Safety in operation requires, at least in a certain sense, a sealed repository. Reparability requires, in a somewhat different sense, an accessible repository. The technical question of how both these requirements can be met simultaneously is still insufficiently explored.

In the second line of reasoning, predicted advances in knowledge played an important role. On the one hand, today we can hardly guarantee that knowledge of how to dispose of nuclear waste will exist for all time. From that perspective, repositories should be constructed so that they will need
no surveillance once they are sealed. Thus, it is our responsibility to come up with a system that will not need active surveillance in order to ensure that safety can be maintained.

On the other hand, it is also conceivable that advances in knowledge will be such that coming generations will have the capacity to deal with nuclear waste in a way that increases safety and/or allows the energy-resources latent in the waste to be put to use. The choice of what to do must devolve upon the generation in question and be based upon its own assessment of the advantages and disadvantages to be encountered. Furthermore, this implies that the repository be designed in such a way as to enable future generations to control it.

These lines of reasoning lead to a double conclusion: A repository should be constructed so that it makes controls and corrective measures unnecessary, while at the same time not making controls and corrective measures impossible. In other words, our generation should not put the entire responsibility for maintenance of repositories on coming generations; however, neither should we deny coming generations the possibility of taking control.

By means of different formulations and by proceeding from various starting-points, a two-edged objective was established vis-a-vis repository facilities: safety in operation combined with reparability, with controls not necessary, but not impossible. Pre-requisites for the realization of this objective are the continued advancement of knowledge and refinement of the qualifications required to deal with nuclear waste.

The objective defined here with the multifaceted motivations expressed at the seminar is wholly in line with the assessments made by the seminar in its entirety, and with its main themes which are presented in this paper.

The Consultative Committee for Nuclear Waste Management intends to continue the study of these questions.
APPENDIX 4

MORAL AND ETHICAL ISSUES RELATED TO THE NUCLEAR FUEL WASTE DISPOSAL CONCEPT

AECL ENVIRONMENTAL REVIEW OFFICE
WHITESHELL LABORATORIES

Hardy Stevenson and Associates

Pinawa, Manitoba ROE ILO
October 1991
"It was conceded that, given the long time frame before a disposal facility is sealed, there is time to identify potential problems and rectify them. It was suggested that we can only make the decisions we are capable of making now, and that people in 75 or 100 years will have to decide whether or not to seal these facilities. All we can do now is decide how things look based upon the best possible information. Given these considerations, it was agreed that we have met our ethical obligations if we make the best decision possible today. We simply have to recognize that in 50 to 100 years, things may be different". (pp. 13-14).

"There is a need to consider the extent to which future generations could benefit from future retrieval, but there is also a need to ensure safety. As a moral issue, the issue of retrieving the used fuel for future use can be seen as a compromise between increased safety and the cost of retrievability. There seems to be agreement that we would be willing to accept higher costs for retrieval in order to emphasize the safety of the disposal concept. This appears to be a reasonable way of discharging our responsibilities". (p. 17).

"We are morally obliged to engage in the most thorough and responsible research program we can establish, in order to make a decision. Even if that decision should turn out to be the wrong one, we will have met our moral and ethical obligations. Society makes decisions that affect future generations; such decisions alter their options. So we should try to minimize adverse effects on them and try not to leave them with unpalatable options. Future generations are, of course, free to make their own choices within what they see as their responsibilities. This includes doing things differently than we would". (p. 17).

The allocation of resources appears to be an important ethical issue, specifically, "How do we allocate resources (and how much do we allocate) in order to maximally reduce risk?" Many members of the public say, for instance, that we should use the most indestructible container; But, in doing so, we take a resource from somewhere else in society (e.g., "With those kinds of funds we can buy a lot of kidney dialysis machines"). It is agreed that this is a fundamental ethical issue that requires further discussion.

On the subject of distribution of resources, there is some feeling that expenditures on waste management should be proportional to the size of harm multiplied by the probability of harm. A particular problem should not receive a vastly disproportionate amount of resources because of its political profile or for some other reason. For example, there are a number of other hazardous-waste management problems that deserve as much attention as this one is getting, but they are not. There is some feeling that a benchmark for the expenditure of resources is required; i.e., we should not be spending vastly more sums of money on one problem than we are spending on others.

We might also ask, "How do we compare the risks of different types of waste?" and "Isn't it important to devote resources in proportion to the degree of hazard?" The latter question raises the issue of perceived versus actual risk.

Application of a distribution of risk concept is problematic because disposal sites for highly toxic waste are sought in less densely populated areas. It is argued that because a site is remote it should not by itself lead to lesser standards of protection for people in the remote region (p. 19).

Taking account of the "non-scientific" cultural view is of great importance, and gives rise to a number of vital questions:

- Where do we begin the ethical reflection on contentious societal issues - at the level of society or of technology?
• How do we deal with cultural differences? Cultural conflict (in a traditional way, e.g., native versus non-native, and in another sense, scientific culture versus non-scientific culture) is alive and well in our society. We deal with problems in science and technology by isolating them and casting them in a manner that is manageable; therefore,

• How are we to deal with the other voices who are critical of the culture of science and technology? (p. 21).
APPENDIX 5

THE POSITION OF THE DUTCH GOVERNMENT ON DEEP BURIAL

The Dutch Government's position on whether deep burial is a feasible and suitable method of disposal for waste (The National Environmental Policy Plan [NEPP]).

May 14, 1993
1. **Introduction**

The National Environmental Policy Plan (NEPP) examines the disposal of non-processable waste in storage facilities or on landfill sites. One of the action points included in the policy plan involves looking at the question of whether such waste can be effectively disposed of by deep burial. Accordingly, the government intends to set out its position on the question of whether deep burial is justified and, if so, under what conditions it might be possible. There are two sides to this question: whether the use of repositories deep underground is consistent with the environmental policy set out by the government in the NEPP and, if this is deemed to be the case, whether it is technically feasible.

Use of deep underground repositories is a particularly strong option for both radioactive and chemical waste which, due to their toxicity, pose a threat to man and the environment. A number of disposal techniques currently used for other types of waste are unsuitable for radioactive and chemical waste. Until suitable disposal techniques become operational, this waste will have to be carefully and completely isolated from the biosphere.

This policy document refers to chemical and radioactive waste which is classified as 'highly toxic waste'. These two types of waste have different characteristics, so joint disposal is not an option. However, the issues involving the use of deep underground storage facilities are the same in both cases. Both categories involve relatively small amounts of waste which, because of its toxicity, must remain isolated from the biosphere for an indefinite period of time.

This joint approach to the problem of disposal obviates the need for a separate set of criteria for the storage of radioactive waste. The Lower House of Parliament was informed accordingly on 22 February 1990\(^1\). At the same time it was pointed out that the promised public consultation procedure should be adapted to reflect the wording of NEPP action point 62, which calls for an assessment of which method of waste disposal is to be preferred, given the government's stated aim of achieving sustainable development. The ultimate choice may have many repercussions. It is therefore important that the decision be taken with care, based as far as possible on relevant arguments. The consultation procedure which formed part of the preparations for this policy document was designed as far as possible to hear such arguments. In the first instance, the views of four organisations with interests in this issue were sought. These were the electricity producers' organisation (SEP), the chemical industry association (VNCI), an environmental group (SNM) and an association of environmental scientists (VVM). They were asked to set out their position on the matter, with a view to distilling a number of relevant arguments which represent the views of the producers of highly toxic waste (SEP and VNCI),

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environmental scientists (VVM) and the environmental movement (SNM). The four organisations were asked to give their views on the following questions:
1. Should waste be disposed of in deep underground repositories?
2. Why/why not?
3. Do these arguments also apply to other forms of waste disposal (above ground)?
4. If waste were to be disposed of deep underground, what conditions should apply?

The various arguments were compared during a one-day seminar.

During the proceedings it became clear that a broader constituency would have to be given the opportunity to make their views known. It was therefore decided that the procedure should be thrown open to anyone who had a point to make; the House was informed accordingly. The open round of consultations was set in motion on 26 October 1991 with an advertisement in the Government Gazette (Staatscourant) and a large number of national and regional newspapers which called for responses to the four questions above. The advertisement attracted a good deal of attention at national and regional level, elicitng in the region of 2,000 responses which were processed by Twente Technical University. A report was drawn up setting out the arguments of the aforementioned organisations and the responses to the advertisement. The report also assessed the accuracy and relevance of the arguments advanced, and identified any connections between them.

2. History

In 1981 the environment and economic affairs ministers of the time set up a committee (known by the acronym ILONA) to supervise research into the possibility of storing radioactive waste underground. This committee commissioned another committee responsible for studying land-based disposal (OPLA) to set up a research programme to look into the possibility of disposal in rock salt formations (particularly salt domes). The programme consists of three phases: (1) research into disposal techniques; (2) identification of potential sites, including field research; (3) detailed study of a particular site. The government of the time was of the opinion that the first phase could go ahead and that, after the results had been evaluated, a decision could be made on starting phases 2 and 3.

The OPLA committee completed phase 1 in 1989, and the Lower House was informed of the results on 15 June of that year. The conclusion was that a storage facility for radioactive waste in rock salt formations in the Netherlands would, in principle, be technically feasible. OPLA had done calculations based on

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models, which led them to expect that it would be possible to store radioactive waste safely in the rock salt formations which occur in the Netherlands. The policy committee, ILONA, advised the government to commission a follow-up study before taking any decisions on phase 2. Phase 1A was therefore initiated, and involves follow-up studies and laboratory measurements. This phase is due for completion in mid-1993.

The 1980s also saw a growing need for a disposal facility for highly toxic chemical waste. In 1987 a report of an official survey of salt mines for non-radioactive waste disposal was published\(^5\). The survey had been conducted in order to ascertain how the most toxic chemical waste (particularly that in the C1 and, to a lesser extent, C2 categories) should be disposed of in future. The report agrees in large part with other studies of the use of salt domes for radioactive waste disposal.

The government and Parliament gradually began to realise that, as well as conducting scientific research to establish whether radioactive waste could be disposed of by deep burial, it was also necessary to develop a set of criteria which could be used to determine whether disposing of radioactive waste in this way was desirable from a social and political point of view\(^6\). The issue of chemical waste disposal also gave rise to the question of whether deep burial is a desirable means of disposal. It has already been indicated in the introduction that, in the implementation of NEPP action point 62, this issue is being considered in connection with both radioactive and chemical waste\(^7\).

3. **Environmental policy**

The basic principles of Dutch environmental policy are set out in the NEPP and its successor, the NEPP+\(^8\). The main plank of the policy is sustainable development, which means satisfying the needs of the present without compromising the ability of future generations to meet their own needs. This fairly broad principle is embodied in, among other things, the more narrowly-defined principle of integrated life cycle management. This involves controlling substance flows produced by economic activity, taking into account their effect on the environment. If the use of primary raw materials (such as ores) gives rise to waste, that waste should be used as a secondary raw material. This will lead to a reduction both in the amount of waste produced and in the wastage and dispersal of primary raw materials.

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6 In response to the Willems motion of 1 October 1984 (Lower House, 1984–1985, 18 343, no. 9), the environment minister stated in a letter to the Speaker of the Lower House that the government was of the opinion that the development of criteria was an essential part of the research. Lower House, 1984–1985, 18 343, no. 16).

7 For a detailed summary of the development of the debate on the storage of highly toxic waste, see “Underground storage of unprocessable waste” by R de Man (1991) which appeared as part of the environment ministry’s series of publications on radiological protection (Publicatiereks Stralenscherming no. 1991/23).


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The memorandum on the prevention and recycling of waste translates the concept of integrated life cycle management into the more concrete aims of waste prevention and "leak-free" disposal. The laws enacted in order to put environmental policy into effect stipulate that production processes must be geared to preventing waste. Any that cannot be prevented must be recycled and, where this is not possible, must be disposed of in an environmentally responsible manner. Recycling involves using a product or material more than once. Some waste cannot yet be recycled. Such waste must be processed or treated so that it can be used in another way, thus extending its useful life. In cases where recycling or processing proves impossible, waste can be used to produce energy; if this, too, is not possible, another form of disposal must be sought; the landfill option is used only as a last resort.

Waste storage facilities and landfill sites must operate in accordance with the ICM criteria (Isolate, Control, Monitor), which involves taking measures to isolate the waste from the biosphere. In addition, control and monitoring ensure that it remains isolated for a sufficiently long period, and these are necessary throughout the entire period of storage or residence at a landfill site.

4. Factors to be considered concerning the disposal of highly toxic waste

The first step in considering the question of using underground repositories for the disposal of highly toxic waste in the light of the waste policy described above is to determine whether this waste flow can be sufficiently reduced by means of prevention and recycling.

It would not at this time be possible to prevent all highly toxic waste without making drastic changes to society. If, for instance, chemical waste were to be banned, the result would be pressure to stop the use of natural gas, from which compounds containing mercury are removed before distribution, leading to the production of C1 waste. If radioactive waste were to be banned, some medical treatments could no longer be carried out. Highly toxic waste is often created during the production of substances which are an essential part of products designed to enhance our health, safety and prosperity. The benefit of processes which create highly toxic waste must therefore be weighed up against the drawbacks associated with that waste. As a consequence of striking that balance, some of these processes will have to continue for the time being. At the seminar referred to above, all the participants acknowledged that it would be difficult to prevent this type of waste.

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10 Waste policy has been incorporated in the new, expanded and amended Environment Management Act, chapter 10 (waste substances), section 10.1, Upper House, 1992–1993, 21 246, no. 60.

11 The ICM criteria are implemented under, among other things, the Soil Protection (Landfill) Decree (Bulletin of Acts and Decrees no. 55; 20 January 1993) which was issued pursuant to the Environmental Management Act and the Soil Protection Act. The criteria are set out in detail in a report by the Soil Protection Technical Committee: "An assessment framework and ICM criteria for local soil pollution"; TCB A90/01, Leidschendam, December 1990.
entirely, although opinions differed on the extent to which it could be prevented.

One must therefore assume that a number of processes will continue to produce highly toxic waste over the coming years. A considerable quantity of this type of waste has already been produced, and it will have to be recycled or put to some other useful application. In the case of highly toxic waste, recycling is only possible if it is done in an environmentally responsible way, in view of the attendant risks to humans and the environment. As with toxic primary raw materials, toxic waste may only be recycled if a sustainable application can be found for it and if dispersal can be prevented throughout its life cycle. These conditions cannot at the moment be met for a large proportion of the toxic waste which exists. However, it is reasonable to expect that recycling methods will be developed for certain categories of waste.

In view of the limited scope for prevention and recycling, some method of disposing of present and future stocks of highly toxic waste must be found. The only suitable method which rhymes with current waste policy would appear to be some form of storage under the ICM criteria.¹²

The government's position on deep underground storage of waste was determined after a number of considerations linked to sustainable development, which were also discussed during the consultation procedure, had been weighed up. The most important of these were:

* Since highly toxic waste cannot be fully recycled and the creation of highly toxic, non-processable waste conflicts with the principle of integrated life cycle management, all steps should be taken to prevent the production of such waste. This consideration has to be weighed up against the effect such a measure would have on a number of useful social processes.
* If waste is stored in such a way that it is naturally isolated, future generations will presumably have few problems with after-care. However, in the long term this would also remove the possibility of control and monitoring, and the option of recycling.
* In normal circumstances, natural isolation makes underground storage a relatively safe means of disposal. However, exceptional or unexpected events may disturb the natural isolating properties of the storage environment, and matters are only made worse by the fact that it is impossible to intervene in such situations.
* Storage in rock salt formations saves space above ground, but means that these formations cannot easily be used for other purposes. This drawback does not arise with storage at the surface, although it does take up more space. However, all types of storage take up a certain amount of space in the surrounding area.

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¹² Other current disposal methods such as distillation, treatment by physical and chemical processes, metal retrieval and incineration are unsuitable since they cannot at the present time be applied to this type of waste. Suitable processing methods are currently being developed or put into operation for some types of waste; see the draft multi-year plan on the processing of hazardous waste. Lower House, 1992-1993, 22 193, no. 6.
The government's position on the storage of highly toxic waste

Given the nature of highly toxic waste, the interests of future generations must be carefully considered when determining whether it would be responsible to store it in deep underground repositories. Having considered the overall environmental policy as set out in the NEPP and NEPP+, waste policy and the arguments put forward in the consultation procedure, the government has adopted the following position on the deep underground storage of highly toxic waste.

* In the light of sustainable development, and particularly from the point of view of integrated life cycle management, the production of highly toxic waste is undesirable. The quantity of highly toxic waste requiring permanent storage can be kept to a minimum if opportunities for prevention and recycling are exploited to the full. To this end, incentives must be created and intensive research must be initiated, or continued where it already exists. For instance, in the case of radioactive waste, the option of actinide incineration\(^\text{13}\) could be examined more closely.

Policy remains focused on encouraging the producers of highly toxic waste to adopt the best available technologies in the short term, and obliging them to justify production of this kind of waste\(^\text{14}\). They must also demonstrate that no acceptable environmentally-friendly alternative exists and that the process is beneficial to society, as well as to the company and to employment figures. Producers of highly toxic waste will also be expected to undertake recycling initiatives, but only if they are environmentally responsible (see section 3). The more environmentally-friendly recycling a company undertakes, the better it will be able to justify its position as a producer of highly toxic waste.

* A facility for long-term storage of highly toxic waste must be created. The government is of the opinion that such a facility must allow retrieval of the waste in the long term for two reasons:

1. Irrespective of its location, a storage facility must be constructed in such a way that it offers maximum safety in normal, exceptional and unexpected circumstances. It must therefore be isolated as well as possible and there must be every opportunity for human intervention in order to carry out control activities; any storage facility which does not meet the ICM criteria will be rejected. To this end the waste must not only be retrievable but the entire process of storage must in principle be reversible in order to render it controllable.

\(^\text{13}\) Actinide incineration involves transmutation from long-lived to short-lived radioactive isotopes, whereby energy production is possible.

\(^\text{14}\) This principle has already been incorporated in policy and enacted in law, see for example the Nuclear Energy Act, the Environmental Management Act and the draft multi-year plan on the disposal of hazardous waste.

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2. In view of the aim of introducing integrated life cycle management for all substances, even in cases where recycling is not currently an option, waste must remain accessible so that, when the opportunity arises, it can be returned to the cycle in an environmentally responsible manner. The government has not, therefore, opted for a permanent method of disposal.

* The retrievability requirement means that future generations will also have a duty of care for highly toxic waste. However, it is reasonable to expect that any drawbacks this might entail in terms of time and money will be outweighed by the importance of the ability to intervene, redesignate and relocate.

* To date, research on the storage of waste in rock salt has focused on permanent storage without the option of retrieval, as a result of the physical properties of rock salt formations, which causes them to seal once the storage facility is closed. The flow behaviour of the rock salt provides relatively good natural isolation. However, storing waste by this method limits the possibilities of gaining access to the waste in order to recycle it and carry out control activities. A storage method which excludes the possibility of retrieval is not in line with the policy outlined in this document. The government therefore rejects non-retrievable storage of waste in rock salt formations deep underground, which is one of the options being studied by the OPLA committee.15

6. Consequences of the government's position on the storage of highly toxic waste

The position set out above offers no solution to the problem of disposing of highly toxic waste. However, the government's policy clearly indicates the direction in which a solution must be sought. To reduce the growth in the volume of highly toxic waste, the options of prevention and environmentally sound recycling must be exploited more fully. When applying for environmental licences, producers of highly toxic waste will have to justify its production, as discussed in section 5. A process which produces this type of waste must be shown to be of great social benefit, and licences should be granted for such processes only as an exception. Producers must at least be obliged to seek out environmentally friendly alternatives, such as recycling.

Processes which give rise to radioactive waste are strictly regulated through a licensing system which is governed by the Nuclear Energy Act. Licences for the use of radioactive substances prescribe all kinds of measures designed to reduce the risks and require that the process itself be justified. Radioactive waste is currently recycled after a number of applications, including radiography. Work will be done to establish how and to what extent it can be recycled after other processes.

15 Research into storage of radioactive waste in geological formations in the Netherlands; final report of phase 1, OPLA. May 1989.
Present and future policy on chemical waste centres on maximum prevention and recycling. The policy is set out in the draft multi-year plan on the disposal of hazardous waste\(^\text{16}\). The plan states that the export of chemical waste for dumping will cease by 1996. It also indicates how chemical waste should be disposed of. The plan is expected to be finalised by mid-1993.

It might be worth considering setting concrete objectives and deadlines for prevention and recycling, as recommended by the Association of Environmental Scientists. Objectives and deadlines for thirty priority substances have already been determined in the memorandum on the prevention and recycling of waste.

Generic research will also have to be carried out to discover a method of storage which fulfils the conditions of retrievability (during the entire storage period) and reversibility. This research will be carried out in an international framework, including at EC level, where the retrievability of waste is beginning to attract attention.

Risk studies will be carried out to compare the safety of above-ground and underground storage alternatives insofar as they are in line with the policy on highly toxic waste set out in this policy document. Costs and safety will be compared. The research will be supervised and financed jointly by the economic affairs and environment ministries, and will aim to give a clearer picture of the options for permanent storage within a few years. Finally, the feasibility of separating waste prior to storage so that it can be recycled in future will be examined.

Current research activities, particularly the work being done on the storage of waste on land (by the OPLA committee), will be assessed in terms of the government's position. The results of the OPLA and actinides research will be reported in further detail in the course of 1993, with an indication of the direction which the studies are to take in the future. The results will be assessed in the light of the government's position and this will determine future direction.

Phases 1 and 1A have produced a huge amount of information on deep underground rock formations in the Netherlands in general, and rock salt formations in particular. Phase 1, in particular, showed that storage in rock salt is in principle technically feasible and that it would be safe to store toxic waste in these formations in the Netherlands. This therefore answers one of the questions posed by the NEPP (can waste be disposed of underground?). This result will also be important in the future, when the feasibility of using the underground for other purposes is assessed.

Appendix

Current policy on highly toxic waste

Current policy on the various types of highly toxic waste is summarised briefly below.

Radioactive waste
Each year some 700m$^3$ of radioactive waste is collected$^{17}$; at the moment this is only low and intermediate level waste (LLW and ILW), which consists largely of contaminated clothing, gloves, laboratory glassware, liquids etc. At a later stage (the late 1990s) highly radioactive waste (HLW) – the waste products of nuclear fission, nuclear fuel, reprocessing waste – will have to be dealt with. This waste is currently in storage at reprocessing plants in Britain and France and at the nuclear power stations in Dodewaard and Borssele. The total volume of HLW created at these two power stations will not exceed the amount of LLW and ILW produced annually.

All radioactive waste is collected by the firm COVRA N.V. and stored at Borssele in such a way that it can be retrieved. The site has enough capacity to last for 50 to 100 years. COVRA’s storage methods are entirely in line with policy on highly toxic waste as set out in this policy document. The costs of storage are borne entirely by the producers of radioactive waste, and amount to approximately 7,000 guilders per 200 litres (approx. 500 kilos). No problems are expected to arise while a more long-term solution is being sought.

Chemical waste
Between 300 and 600 tonnes of category C1 chemical waste are produced each year, and consist mainly of mercury compounds released during the extraction of natural gas (several hundred tonnes) and the processing of corona discharge lamps (several hundred tonnes), and from hardening salts used in the steel processing industry (several dozen tonnes). It costs some 600 to 1,200 guilders to dispose of a tonne of C1 waste. A great deal more category C2 waste is produced each year (approx. 30,000 tonnes). C2 waste consists of various types of sludge, pigments, salts and metallic compounds (some containing heavy metals). Storage costs some 500 to 700 guilders a tonne.

C1 category waste is currently being stored in German salt mines, in such a way that it can be retrieved while the mine is in operation, which is expected to be the case for a number of decades. C2 waste is at present in storage above ground in accordance with the ICM criteria and is also retrievable.

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$^{17}$ Site-based environmental impact report; reprocessing and storage of radioactive waste, Sloe site; COVRA N.V., January 1989.
ANNEX II

LIST OF PARTICIPANTS
LIST OF PARTICIPANTS

Chairman: Dr. Ron Flowers

Invited Speakers

Dr. John F. AHEARNE, Executive Director of Sigma Xi, P.O. Box 13975, Research Triangle Park, NC 27709, United States.

Dr. Colin J. ALLAN, Vice-President, Physical and Environmental Sciences, Atomic Energy of Canada Limited, Whiteshell Laboratories, Pinawa, Manitoba ROE 1LO, Canada.

Mr. Maurice ALLEGRE, President, Agence Nationale pour la Gestion des Déchets Radioactifs (ANDRA), Route du Panorama Robert Schuman, B.P. 38, 92266 Fontenay-aux-Roses, France.

Dr. Frans BERKHOUT, Research Fellow, Science Policy Research Unit, Mantell Building, University of Sussex, Falmer, Brighton BN1 9RF, United Kingdom.

Prof. Bayard L. CATRON, The George Washington University, Department of Public Administration, 2115 G. Street NW, Room 302, Washington D.C. 20052, United States.

Mrs. Herlind GUNDELACH, Ministerialrätin, Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (BMU), Z II 1, Postfach 12 06 29, D-53117 Bonn, Germany.

Mr. Bill L. LONG, Director, OECD Environment Directorate, 15, boulevard Amiral-Bruix, F-75016 Paris, France.

Mr. Victor MORGENTHOTH, Environmental Health and Safety Division, OECD Environment Directorate, 15, boulevard Amiral-Bruix, F-75016 Paris, France.

Mr. Yves QUERE, Directeur des Etudes, Ecole Polytechnique, 91128 Palaiseau, France.

Mrs. Kristina von REIN, Section for Hazardous Waste and Site Remediation, Swedish Environmental Protection Agency, S-171 85 Solna, Sweden.

Mr. Fred ROOTS, Science Advisor Emeritus, Department of the Environment, 3rd Floor, Jules Leger Building, 10 Wellington Street, Hull, Quebec K1A 0H3, Canada.

Participants

AUSTRIA - AUTRICHE

Dr. Peter KREJSA, Head, Waste Management, Österreichisches Forschungszentrum Seibersdorf, A-2444 Seibersdorf.
BELGIUM - BELGIQUE

Dr. Paul DEJONGHE, Conseiller Général, Centre d’Etude de l’Energie Nucléaire, 200 Boeretang, B-2400 Mol-Donk.

Mr. Jean VAN MIEGROET, Directeur Etudes et Evacuation, Organisme National des Déchets Radioactifs et des Matières Fissiles, ONDRAF/NIRAS, Place Madou 1, Boîtes 24/25, B-1030 Brussels.

CANADA

Dr. Peter A. BROWN, Director, Radioactive Waste and Radiation, Electricity Branch, Natural Resources Canada, 580 Booth Street, Ottawa, Ontario K1A OE4.

Ms Mary GREBER, Manager, Public and Government Affairs, Atomic Energy of Canada Limited, Whiteshell Nuclear Research Establishment, Pinawa, Manitoba ROE 1LO.

FINLAND - FINLANDE

Mrs. Margit HOVI, Senior Adviser, Ministry of Trade and Industry, Energy Department, P.O. Box 37, SF-00131 Helsinki.

Mr. Tero VARJORANTA, Finnish Centre for Radiation and Nuclear Safety, P.O. Box 14, SF-00881 Helsinki.

FRANCE

Mr. Denis ALEXANDRE, Département Stockage Déchets, DSD/CSC, CE/Cadarache, 13108 St-Paul-lez-Durance Cedex.

Mr. Pierre. BARBER, Relations Internationales, Agence Nationale pour la Gestion des Déchets Radioactifs (ANDRA), Route du Panorama Robert Schuman, B.P. 38, 92266 Fontenay-aux-Roses.

Mr. Jean LEFEVRE, Conseiller Scientifique du CEA pour l’aval du cycle du combustible, Direction du Cycle du Combustible, Commissariat à l’Energie Atomique, Bâtiment 121, Centre d’Etudes Nucléaires de Saclay, F-91191 Gif-sur-Yvette Cedex.

GERMANY - ALLEMAGNE

Dr. Manfred BLOSER, Ministerialrat, Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (BMU), RS III 6, Postfach 12 06 29, D-53117 Bonn.

Dr. Diethard LUMMERZHEIM, Head of Waste Management Division, Bundesministerium für Forschung und Technologie, Godesberger Allee 185-189, Postfach 200240, D-53170 Bonn.

Prof. Dr. Helmut RÖTHEMEYER, Director, Nuclear Waste Disposal, Bundesamt für Strahlenschutz, Postfach 100149, D-3320 Salzgitter 1.

JAPAN - JAPON

Mr. Masahide OSAWA, Power Reactor and Nuclear Fuel Development Corporation (PNC), Sankaidho Building, Akasaka 1-9-13, Minato-ku, Tokyo 107.
THE NETHERLANDS - PAYS-BAS

Dr. Wim A. SMIT, School of Philosophy and Social Sciences, Department Philosophy of Science and Technology TW-RC Building, r. RC-310, University of Twente, Postbus 217, 7500 AE Enschede.


NORWAY - NORVEGE

Mr. Gordon C. CHRISTENSEN, Head, Health and Safety Department, Institutt for Energiforskning, Postboks 40, N-2007 Kjeller.

SPAIN - ESPAGNE

Mr. Pedro CARBONERAS, ENRESA, Calle Emilio Vargas, 7, 28043 Madrid.

Dr. Antonio DE ACHA ARACAMA, Subdirector for Siting, Consejo de Seguridad Nuclear, c/Justo Dorado, 11, 28040 Madrid.

SWEDEN - SUEDE

Mr. Per-Eric. AHLSTRÖM, Vice-President, Swedish Nuclear Fuel and Waste Management Company (SKB), Box 5864, S-102 40 Stockholm.

Dr. Conny HÄGG, Swedish Radiation Protection Institute (SSI), S-17116 Stockholm.

Mr. Sören NORRBY, Director, Office of Nuclear Waste, Swedish Nuclear Power Inspectorate (SKI), Box 27106, S-102 52 Stockholm.

Mr. Claes THEGERSTRÖM, Director, Deep Repository, Swedish Nuclear Fuel and Waste Management Co. (SKB), Box 5864, S-102 40 Stockholm.

SWITZERLAND - SUISSE

Dr. Charles McCOMBIE, Director, Science and Technology, Société Coopérative Nationale pour l'Entreposage de Déchets Radioactifs (NAGRA), Hardstrasse 73, CH-5430 Wetzlingen.

Dr. Beat WIELAND, Chef de la Section Technologie Nucléaire et Sûreté, Office Fédéral de l'Energie, CH-3003 Bern.

Dr. Auguste ZURKINDEN, Head, Section for Radioactive Waste Management, Swiss Nuclear Safety Inspectorate, CH-5232 Villigen-HSK.

UNITED KINGDOM - ROYAUME-UN

Dr. Steven BROWN, Head of Radioactive Substances Division, Department of the Environment, Room A5.16, Romney house, 43 Marsham Street, London SW1P 3EB.

Dr. Ron H. FLOWERS, Nuclear Technology Consultant, Stewart Memorial, The Street, Brightwell-cum-Sotwell, Wallingford, Oxfordshire OX10 ORR.


CEC - CCE

Mr. Karl SCHALLER, Division Cycle du Combustible Nucléaire et Politique des Déchets, Commission des Communautés Européennes, Direction générale XI D, 200 rue de la Loi, B-1049 Bruxelles, Belgique.

IAEA - AIEA

Dr. Ernst WARNECKE, RADWASS Programme Co-ordinator, Division of Nuclear Fuel Cycle and Waste Management, International Atomic Energy Agency, P.O. Box 100, A-1400 Vienna, Austria.

NEA - AEN

Dr. Kunihiko UEMATSU, Director General, OECD Nuclear Energy Agency, Le Seine Saint-Germain, 12, boulevard des Iles, 92130 Issy-les-Moulineaux, France.

Mr. Sam THOMPSON, Deputy Director General, OECD Nuclear Energy Agency, Le Seine Saint-Germain, 12, boulevard des Iles, 92130 Issy-les-Moulineaux, France.

NEA SECRETARIAT

Mr. Jean-Pierre OLIVIER, Head, Radiation Protection and Waste Management Division, OECD Nuclear Energy Agency, Le Seine St-Germain, 12, boulevard des Iles, 92130 Issy-les-Moulineaux France.
Environmental
and ethical aspects
of long-lived
radioactive waste disposal

All countries engaged in nuclear production give special attention to the safe disposal of radioactive waste, particularly concerning long-term protection of humans and the environment. Many other countries using radioactive materials for medical, industrial or research purposes only are also concerned by this issue. Practically speaking, all countries are generally interested in keeping abreast of the development of radioactive waste management policies and of underlying technical and non-technical studies.

These issues and their influence on the decision-making process were examined at a special workshop of the NEA Radioactive Waste Management Committee. This volume presents the full proceedings of that workshop, including papers and transcribed discussions, which sought to provide a broad basis for an in-depth reflection on long-term disposal issues.