nwmo
NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

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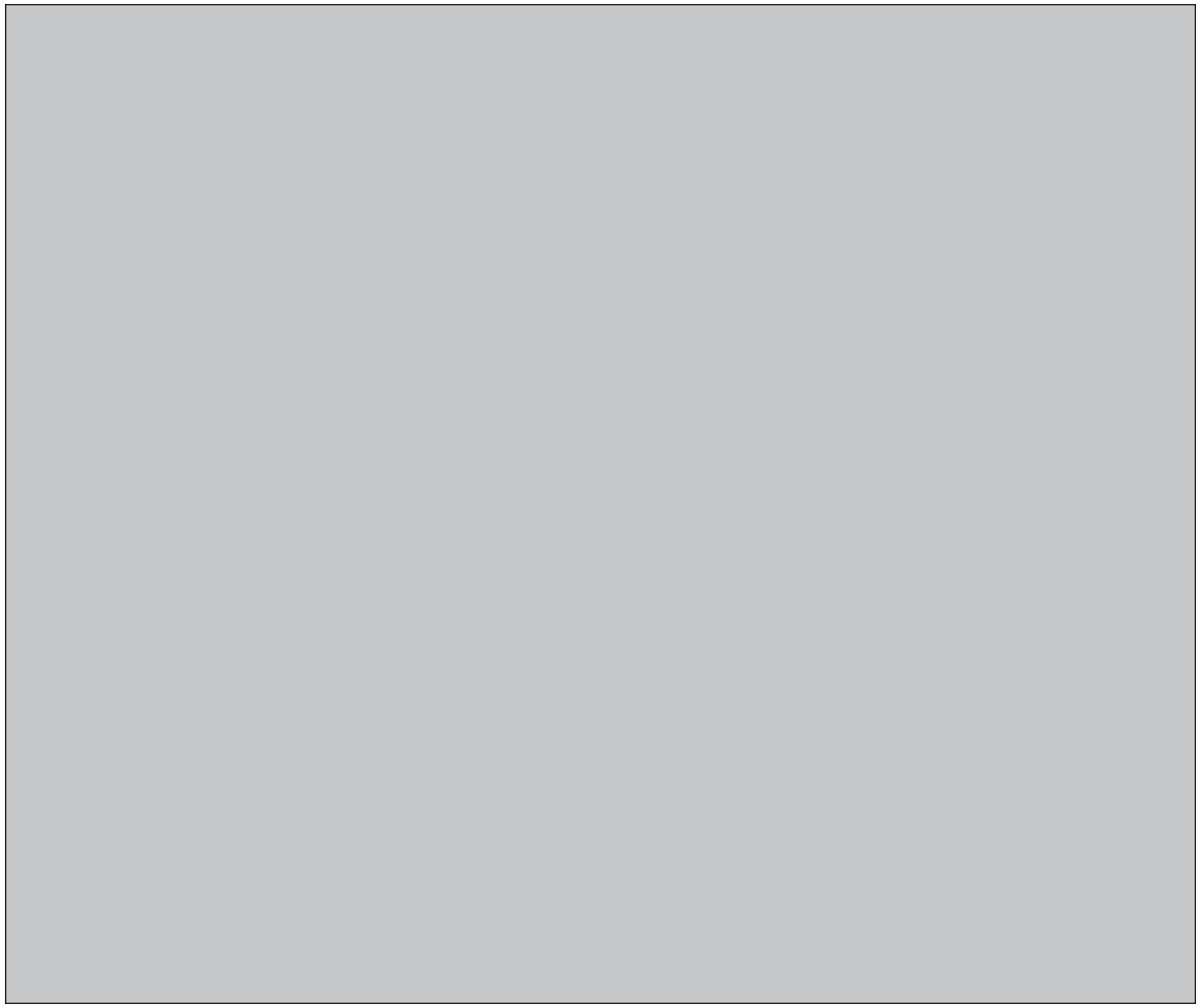
NWMO BACKGROUND PAPERS
5. ECONOMIC FACTORS

5-3 CONSIDERATIONS FOR THE ECONOMIC ASSESSMENT OF APPROACHES TO THE LONG-TERM MANAGEMENT OF HIGH-LEVEL NUCLEAR WASTE

Charles River Associates Canada Limited



NWMO Background Papers

NWMO has commissioned a series of background papers which present concepts and contextual information about the state of our knowledge on important topics related to the management of radioactive waste. The intent of these background papers is to provide input to defining possible approaches for the long-term management of used nuclear fuel and to contribute to an informed dialogue with the public and other stakeholders. The papers currently available are posted on NWMO's web site. Additional papers may be commissioned.

The topics of the background papers can be classified under the following broad headings:

1. **Guiding Concepts** – describe key concepts which can help guide an informed dialogue with the public and other stakeholders on the topic of radioactive waste management. They include perspectives on risk, security, the precautionary approach, adaptive management, traditional knowledge and sustainable development.
2. **Social and Ethical Dimensions** - provide perspectives on the social and ethical dimensions of radioactive waste management. They include background papers prepared for roundtable discussions.
3. **Health and Safety** – provide information on the status of relevant research, technologies, standards and procedures to reduce radiation and security risk associated with radioactive waste management.
4. **Science and Environment** – provide information on the current status of relevant research on ecosystem processes and environmental management issues. They include descriptions of the current efforts, as well as the status of research into our understanding of the biosphere and geosphere.
5. **Economic Factors** - provide insight into the economic factors and financial requirements for the long-term management of used nuclear fuel.
6. **Technical Methods** - provide general descriptions of the three methods for the long-term management of used nuclear fuel as defined in the NFWA, as well as other possible methods and related system requirements.
7. **Institutions and Governance** - outline the current relevant legal, administrative and institutional requirements that may be applicable to the long-term management of spent nuclear fuel in Canada, including legislation, regulations, guidelines, protocols, directives, policies and procedures of various jurisdictions.

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1. Executive Summary

1.1. OBJECTIVES OF THIS REPORT

The Nuclear Waste Management Organization's (NWMO) mandate is to study and recommend a preferred approach for the long-term management of high-level nuclear waste.[1] The process of developing recommendations for the federal government that meet technical, ethical, and economic objectives while also enjoying public acceptance must be one that starts with a thorough exploration of the decision-making processes and evaluation criteria that will be used. These analytic structures will be drawn from a number of disciplines, including economics. This report addresses only the economic perspective.

Charles River Associates Canada Limited (CRA) has been retained to develop an understanding of the economic perspective on the NWMO's mandate. The objectives of this report are:

- To identify some of the key financial and economic issues that will need to be considered in evaluating and comparing alternative approaches to long-term management of high-level nuclear waste

- To frame a discrete number of economic/financial questions for use in that evaluation

- To explore the key assumptions underlying how the economic/financial questions have been framed and will be analysed

- To develop preliminary suggestions on the methods that might be adopted in addressing the need for a deeper understanding of the economic and financial issues

The NWMO's task is a complex one, both because of the issues inherent to the management of nuclear waste, as well as to the great uncertainties and heightened concerns that will frame any discussion around a topic as emotive as nuclear waste, including as it does concerns for safety, the environment and inter-generational transfers. Nonetheless, it is important that the NWMO seeks to identify and recommend the optimal solution.

[1] Section **12.** (2) of the *Nuclear Fuel Waste Act* directs the NWMO to examine, at a minimum, three waste management approaches: deep geological disposal in the Canadian Shield; storage at nuclear reactor sites; and centralized storage, either above or below ground. Throughout this paper we refer to the long-term "management" of waste as being an umbrella concept encompassing both "storage" – which implies there is a provision for retrieval, and "disposal" – where placement is permanent with no intention of retrieval.

The approach taken here is not that of the economic purist. From our experience in this field an approach to long-term nuclear waste management that is not the economically preferred alternative may still be the wisest policy choice if it can garner sufficient timely consensus to be doable. This may be contrasted with an economically preferred alternative that fails to gain adequate support across society and thus cannot be implemented in a reasonable amount of time.

The underlying objective of this report is to assist the NWMO in establishing a sound framework in which to undertake various economic analyses over the next two years; understanding how different economic tools could be used to contribute to its decision-making processes; and appreciating some of the key questions, assumptions, and practical challenges that must be addressed.

1.2. STRUCTURE OF THE REPORT

Section 2 of the report discusses different ways in which the NWMO may wish to use economic analysis, how the basis for economic analysis might be established, and how the outputs of economic analysis may be used to assist the NWMO in its process of developing recommendations on approaches to nuclear waste management.

Section 3 describes some of the particular challenges faced in examining an issue like long-term nuclear waste management and sets out a number of questions that can both guide the framing of the economic analysis and more precisely highlight the specific analytical challenges inherent in the issues facing the NWMO.

The appendix provides more detail on various forms of economic analysis.

2. Applying Economic Analysis

Section 2.1 outlines the role economic analysis can play in the policy-making process with reference to the issues implicit in the long-term management of high-level nuclear waste.

Section 2.2 considers some of the contextual and structural/analytic issues that must be addressed before conducting an economic analysis.

2.1. VARIOUS KINDS OF ECONOMIC ANALYSIS

The fundamental[2] questions underlying economic analyses of public sector projects typically include the following:

- Should a project be undertaken on economic efficiency grounds? That is, will the project increase overall social welfare?

- Among competing project alternatives which will provide the greatest increase in overall social welfare; or which one will provide the greatest ratio of social benefits to social costs?

These two questions lend themselves to economic welfare analyses, such as benefit-cost analysis. Benefit-cost analyses also may examine the distribution of benefits and costs across specific groups within society that are of particular importance with regard to the issue at hand. Benefit-cost analysis can demonstrate whether a project is economically "positive" or "negative," as well as define the rank order and net benefits of different project approaches.

Where the focus of attention is directed at developing a better understanding of how a project's effects on such factors as employment, incomes, and profits, might be distributed among various groups of people (regions, industries, social groups, between generations, etc.), economic impact analysis would be applied.

While these approaches share common methodological toolsets, it is important to clarify at the outset the nature of the question being posed and the context within which it is hoped economics can advance understanding. Since the analytic responses noted above are fundamentally distinct,

[2] As opposed to more applied matters of determining the accounting stance, choosing discount rates, incorporating risk and uncertainty, modelling market impacts, assessing financing options, etc.

it is important to define the fundamental questions carefully. For a more detailed discussion, the various approaches and the distinctions between them can be found in the appendix.

Before employing economic tools one must first determine what sort of questions are being asked of the NWMO, and then, secondly, shape an approach to integrating the economic insights with the insights from other streams of thinking (technical analysis, ethical considerations, environmental stewardship, etc.).

2.2. FRAMEWORK CONSIDERATIONS IN APPLYING ECONOMIC ANALYSIS TO THE ISSUES THE NWMO FACES

To ensure an effective decision-making process and to avoid wasteful expenditure of resources analysing approaches that can be identified as non-starters from the outset, it is critical to have a clear sense of scope, assumptions, objectives, and constraints. For example:

- Have ethical, environmental, legal, or political analyses determined that certain approaches absolutely should not be considered?

- What is the breadth of the problem – e.g., how much waste must be managed and what are the assumptions regarding the life-span of reactors?

- What priorities are to be assigned among such competing interests as overall project cost minimization, contribution to nuclear weapons non-proliferation efforts, promotion of civilian nuclear technology exports, reducing burdens to (or increasing choices for) future generations, or assuaging public doubts and fears?

Looking more narrowly at the economic analysis stream of the NWMO's mandate, a useful initial focal point is the question of how benefits are to be defined.

Typically, economic analyses of projects measure benefits as society's willingness to pay for the outputs of the project. With regard to the long-term management of high-level nuclear waste, the benefits can conceptually be divided into two broad categories:

1. The avoided costs to society (in certain alternatives) both of rationalizing or eliminating the long term cost of waste management and of reducing the potential costs of future accidents, etc.

2. The "relief" factor (or the inverse of the "dread" factor), specifically the lessening of public fears and anxieties when the problem is perceived to have been satisfactorily addressed.

In both cases, uncertainty and measurement difficulties will complicate the analysis. What is important to recognize is that the economic analytic approach provides a method for integrating such disparate considerations.

Given the uncertainties inherent in the analysis of long-term nuclear waste management issues, we would caution that economic analyses should not be expected to necessarily yield discrete values for any approach. Rather, it should be looked to, perhaps, as a way of shedding light on the relative values of alternatives. Indeed we would expect that economic analytic techniques would help the NWMO to assess the value and importance of certain considerations and leave other factors as "unknowables". The economic insights, when combined with other inputs to the NWMO process, could then drive the selection of preferred alternatives.

The matrix below illustrates at a high level one approach that might be taken to incorporating economic and other considerations. The three approaches already under examination, plus some additional ones, are reflected in the columns across the table. Down through the rows are some of the various disciplines that need to be incorporated into the process of developing the NWMO's policy recommendations.

Decision Inputs	**Approaches Considered**				
	On-Site Storage	*Centralized Storage*	*Deep Geological Disposal*	*Variant Approach*	*Completely New Approach*
Economic Insights					
Clearly definable financial and economic insights					
Areas of economic insight and contribution where measurement difficulties and uncertainty may reduce the decisive impact of the insights					
Distributional insights					
Ethical Perspectives					
Technical Considerations					
Environmental Considerations					
Other Considerations					

Once the various cells in the table were populated with more detailed analytical insight, this would need to be evaluated, weighed, and compared with the perspectives both across the alternatives and across the disciplines within the analytic framework.

The completed matrix would illustrate how important particular questions and assumptions will be to comparing alternative approaches as well as the degree of precision and confidence that would accompany any eventual conclusions.

3. Unique Challenges and Questions Facing the NWMO

The issue of nuclear waste management presents unique challenges for economic analysis, and indeed for any other disciplined consideration as well. One critical factor is that some portions of the waste will remain radioactive for tens of thousands of years.

Basic assumptions implicit in most types of economic analysis become questionable with such a long time horizon. Nuclear waste issues present questions with regard to assessing the economic implications of events that may have an extremely low probability of occurrence but that could have catastrophic effects if they did occur. Furthermore, any economic analysis of the issue would need to consider the intangible but nonetheless very real "dread factor" that underlies public perceptions of nuclear waste.

As noted at various points above, three fundamental difficulties profoundly will affect economic analysis of nuclear waste alternatives. These are risk and uncertainty; long timelines; and the non-quantifiable nature of importance considerations such as public fear. Considering these challenges and the various forms of economic analysis discussed previously, we suggest that the following set of broad questions provides a reasonable summary of issues and starting point for deeper economic analyses. We have grouped these questions into five areas:

1. What are the proper boundaries for economic analysis?

    a. What is the appropriate accounting stance? That is, for the assessment of social benefits and costs, which "society" is relevant – Canada as a whole? Ontario, Quebec, and New Brunswick?

    b. How much waste must be managed and what are the assumptions regarding the life-span of reactors?

    c. How important are issues such as the effect of various waste management approaches on possible proliferation of nuclear weapons?

    d. How many variants on the three basic management approaches should be considered?

    e. What types of sensitivity analyses should be performed?

2. What sort of distributional impacts should be considered?

    a. Which, if any, groups within the broader society should be identified for more precise analysis with regard to welfare effects and/or economic impacts?

    b. Should significant negative impacts on certain groups be tantamount to a veto on a particular approach?

    c. What types of compensation schemes could or should be considered for those who would otherwise be net losers under a particular approach?

3. How should intergenerational transfer issues be viewed considering the uncertainty created by extremely long timelines?

    a. What impacts might future wars, social upheavals, or natural disasters have on Canada's (and others') political and financial institutions, and what does this imply for assumptions about long-term management financing arrangements?

    b. How could the risk of human, technological, or institutional failure hundreds or thousands of years into the future be estimated and modelled?

    c. How could the potential for technological improvements hundreds or thousands of years into the future be taken into consideration?

    d. How do we predict future generations' choices of energy generation sources?

    e. If nuclear fission reactors continue to be used, then perhaps society will never reach the point of being able to close its disposal facilities: what would this mean for the application of the polluter-pays principle, and would this lessen the argument that future generations should not bear the burden of waste management?

    f. Recognizing that the choice of discount rate can have profound effects on the assessment and ranking of options, what discount rate should be applied?[3]

4. How could an approach that involved significant long-term management responsibilities be financed?

[3] We note that there is a considerable literature on this topic that will be useful to more in-depth considerations of the question.

a. How could any fund set aside for such costs be secure – both from future raids on any surpluses, as well as against future declines in value or increases in management costs?

b. What are the reasonable contingencies to consider: do transportation accidents require a particular fund, what about economic recessions that reduce the funds available?

c. What about extremely rare but potentially catastrophic events (such as an asteroid strike on a deep geologic disposal site)?

d. In applying the principle of "polluter pays," nuclear waste nonetheless imposes enormous contingent liabilities on the state and on future generations. To what extent does the transfer of contingent liabilities to state bodies imply a subsidy for nuclear generation?

5. What would the financial ramifications of various waste management approaches mean for the future viability of the nuclear industry itself?

    a. Are certain approaches sensitive to economies of scale?

    b. If additional future waste streams were anticipated, might this justify investing now in a more expensive approach than if the existing streams of waste were expected to end soon? That is to say, what degree of scalability is desirable in the waste management options?

    c. Given that the cost of management imposed on present waste generators may impact the future use of nuclear materials, where are the tipping points in this balance?

All these questions lead towards determining the types of economic analyses that should be employed, as well as identifying and weighting the analytic outputs that should be among the NWMO's decision criteria. It will be useful for the NWMO to engage stakeholders early in the process to consider these questions and forge consensus on framework issues before more detailed analysis begins.

Appendix – Options for Economic Analysis

Public sector projects typically undergo one or more types of economic analysis, in addition to or in conjunction with other forms of assessment – sociological, legal, political, or environmental, for example.

Social benefit-cost analysis is frequently employed to assess a project or to compare alternative project options. This tool's focus is to determine the impact on overall social welfare: will the project(s) make society better off or worse off, and by how much?

A variation on benefit-cost analysis is cost-effectiveness analysis, where an outcome is defined and project options are assessed to see which one can produce that outcome at the lowest cost. This tool is appropriate where there are particular difficulties in estimating benefits.

In conducting these types of social welfare analyses, impacts on particular subsets of society also may be examined where these distributional effects are of interest to decision-makers.

At a more mechanical level, financial analysis may be required to determine the most efficient and most prudent method of funding a project. Econometric and/or game theoretic analyses also may be useful or necessary to estimate values for particular aspects and effects of a project.

Also, where policy-makers have a goal, for example, of generating economic "development" in a particular area, an economic impact assessment may be conducted to see what level of economic activity a project will spur within that area. Note that social welfare analyses (benefit-cost or cost-effectiveness) and economic impact analysis have distinctly different perspectives: for example, in a benefit-cost analysis, the labour used in a project is a "cost" – through employment on the project these resources are unavailable for the opportunity to work on other projects; in an economic impact assessment, at least some of the labour used in a project may be categorized as "job creation" – an economic plus.

A social welfare analysis can be thought of as having four broad stages:

1. Identification – a listing of the effects of the project

2. Classification – specifying effects as benefits or costs (except that in cost-effectiveness analysis a specific outcome is provided, rather than benefits being measured)

3. Quantification – in short, benefits are generally assessed in terms of society's willingness to pay for the outputs of the project; costs are assessed as the opportunity cost of the resources used in the project

4. Presentation of results – as noted above, the primary focus of benefit-cost and cost-effectiveness analyses is the impact on overall social welfare, but more precise distributional effects may be presented if these are important to decision-makers

At the outset, the "accounting stance" must be determined. What is the "society" in question? For a sewer upgrade in a small town that is to be funded through the municipal tax base, it would be appropriate to choose the perspective of that town as the accounting stance.[4] Conversely, if the federal government were to consider options for a nation-wide program to monitor the incidence of West Nile Virus in birds, then the appropriate accounting stance would be Canadian society as a whole.

A second key factor is the choice of discount rate(s) to be applied to benefits and costs that occur in the future. Because funds for public sector projects must come ultimately from the private sector, there is a view that the opportunity cost of capital in the private sector is the appropriate discount rate.[5] Another approach (and one that is much easier to apply in a practical sense) is to use the rate at which the government in question can borrow funds, i.e., its long-term bond rate (presuming a long-term project).

When estimating various costs and benefits, special consideration is required where the good is a public good[6] or where the project itself is of significant magnitude to affect market prices of its own inputs and outputs.

Finally, it is worth noting some of the basic assumptions generally underlying social benefit-cost analysis. First, it is generally assumed that the marginal utility of income is constant throughout the population within the accounting stance. Where there are important distributional concerns, this assumption may require modification. Second, benefit-cost analyses are typically run to only 30-50 years or so as the effect of discounting generally makes any values beyond that point inconsequential to the results of the analysis. Third, there is an implied assumption of basic social, political, and economic stability throughout the life of the project. Obviously in the case

[4] Meaning that any effects – positive or negative – on other towns and villages in the area would be excluded from the analysis.

[5] *Benefit-Cost Analysis: A Practical Guide*, Lee Anderson and Russell Settle, Lexington Books, pp. 82-90.

[6] A public good, as opposed to a private good, is defined as a good that is non-rival in consumption and for which it is impossible or impractical to exclude any one consumer. The light from a streetlamp is a classic example: one passerby's enjoyment of the light does not diminish the enjoyment of anyone else, and it would be impractical to try to prevent any one passerby from enjoying the streetlamp's illumination of the street.

of nuclear waste issues it is more difficult to rely on this assumption given the extraordinarily long time frames involved.