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ÉNERGIE ATOMIQUE
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**NUCLEAR ENERGY INQUIRIES
NATIONAL AND INTERNATIONAL**

**ENQUÊTES SUR L'ÉNERGIE NUCLÉAIRE
À L'ÉCHELON NATIONAL ET INTERNATIONAL**

J.A.L. ROBERTSON

25/08

Chalk River Laboratories

Laboratoires de Chalk River

Chalk River, Ontario K0J 1J0

February 1993 février

AECL Research

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by

J.A.L. Robertson

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EACL Recherche

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RÉSUMÉ

Notre choix de sources d'énergie a des conséquences importantes pour l'économie et pour l'environnement. L'énergie nucléaire est une source d'énergie sujet à controverse et à longues discussions publiques. La plupart des gens ont du mal à se décider entre les affirmations et allégations contradictoires sur divers sujets techniques. Dans ces circonstances, il peut être utile de connaître les résultats de diverses enquêtes pertinentes. On résume dans ce rapport l'ensemble et les principales conclusions de plus de trente enquêtes sur l'énergie nucléaire. La plupart de ces enquêtes sont canadiennes mais d'autres y sont incluses lorsqu'elles sont appropriées. L'étude montre que, contrairement à certaines affirmations, on a soumis pratiquement tous les aspects de l'énergie nucléaire à un examen minutieux. Les rapports d'enquêtes comportent de nombreuses recommandations quant à la *façon dont* on peut exploiter l'énergie nucléaire sans danger, mais aucun ne la rejette comme source d'énergie convenable si besoin est.

Division des Services de soutien
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Laboratoires de Chalk River
Chalk River (Ontario) K0J 1J0

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ABSTRACT

Our choice of energy sources has important consequences, for the economy and the environment. Nuclear energy is a controversial energy source, subject to much public debate. Most individuals find it difficult to decide between conflicting claims and allegations in a variety of technical subjects. Under these circumstances, knowledge of various relevant inquiries can be helpful. This publication summarizes the composition and major findings of more than thirty nuclear energy inquiries. Most of these are Canadian, but others are included where they have relevance. The survey shows that, contrary to some claims, virtually every aspect of nuclear energy has been subject to detailed scrutiny. The inquiries' reports include many recommendations on *how* nuclear energy can be exploited safely, but none rejects it as an acceptable energy source when needed.

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Those who do not study history are doomed to repeat it. - George Santayana

It's not that people know too little — It's that they know too many things that just ain't so. - Mark Twain

1. INTRODUCTION

Our choice of energy sources has important consequences, for the economy and the environment. Nuclear energy is a controversial energy source, subject to much public debate. However, modern technologies are sufficiently technical and complex that members of the general public are often unable to assess the risks to which they are exposed. They have to rely on regulatory bodies staffed by specialists. This reliance is not unconditional, however: many of these technologies have been the subject of scrutiny by independent international councils, among others. And, in a democracy, they are all eventually subject to approval by elected representatives.

Most individuals find it difficult to decide between conflicting claims and allegations in a variety of technical topics. Under these circumstances, knowledge of various relevant inquiries can be helpful.

This publication summarizes the composition and major findings of more than thirty nuclear energy inquiries. It is intended to provide a survey of all relevant Canadian inquiries, but environmental assessments and hearings of the National Energy Board are too narrow in scope. Other inquiries are included where they have relevance. Within each national, or international, grouping the presentation is chronological. The Canadian inquiries, however, are postponed till after some major and general topics have been covered in the national presentations. Documentation for the inquiries and a brief subject index are provided at the end.

2. UNITED KINGDOM

2.1 Royal Commission on Environmental Pollution, 1976 (Sir Brian Flowers)

"The Flowers Report" was the first of a series of major reviews of nuclear energy around the world. Because it was the first, and because of the high quality of the introductory chapters that are universally applicable, it has been widely quoted. However, its conclusions have to be considered in the context of the U.K.'s situation in the mid-1970s.

At that time, the U.K.'s nuclear program was still based on gas-cooled graphite-moderated thermal reactors, and was planning for the commercial introduction of liquid-metal-cooled fast reactors by the end of the century. There was still no intention to introduce the U.S. design of a light-water reactor, and uranium shortages within a few decades were foreseen. The Royal Commission on Environmental Pollution, a prestigious standing commission, decided in 1974 to investigate the environmental risks that might be associated with the projected growth in nuclear energy, with emphasis on the long term. The Chairman appointed for this commission was Professor Sir Brian Flowers, then Rector of Imperial College of Science and Technology in London.

The extreme diversity of interests and expertise represented in the 16 members of the commission resulted in a report containing many two-handed statements ("on the one hand this, but on the other hand that"). Thus both proponents and opponents of nuclear energy have attacked some of its conclusions, and then proceeded to quote others. This should not obscure the real achievement of the commission in arriving at a consensus on so many points.

In the matter of health effects of radiation, it concluded that:

No-one who surveys the field of radiological protection can fail to be aware that the hazards of ionising radiation are well appreciated, and that there is, as has been for a long time, an elaborate system of national and international bodies which work together to minimise the potential dangers. . . . We have been impressed by the relatively much stricter regime that prevails with respect to ionising radiation than in the field of toxic chemicals. The result has been an exemplary record in the nuclear industry world-wide of protection of the health of both radiation workers and the general public. Indeed, we are strongly of the view that many of the practices for the protection of human health that are common in the radiation field could and should be adapted for application in other areas. . . .

. . . there is no better way of deriving basic standards than on ICRP [International Commission on Radiological Protection] recommendations, given that the scientific standing and independence of its members is maintained. . . .

It is difficult to think of any other form of pollution that has had its effects on man so well examined as has ionising radiation. . . . There does appear to be more agreement over what can be tolerated than there is for most other pollutants.

It dismissed as unfounded the claim by John Gofman, then receiving widespread publicity, that small particles of plutonium presented a special carcinogenicity (the "hot particle" theory).

The commission endorsed the safety and value of the U.K.'s program for existing and planned thermal reactors:

The risk of serious accident in any single reactor is extremely small; the hazards posed by reactor accidents are not unique in scale nor of such a kind as to suggest that nuclear power should be abandoned for this reason alone. . . . The abandonment of nuclear fission would . . . be neither wise nor justified. . . . We accept the need to retain a nuclear option.

However, concerns were expressed over the long-term program, and it was on these that the critics focussed their attention. Statements such as:

The dangers of the creation of plutonium in large quantities in conditions of increasing world unrest are genuine and serious. We should not rely for energy supply on a process that produces such a hazardous substance as plutonium unless there is no reasonable alternative. . . .

and

A major commitment to fission power and a plutonium economy should be postponed as long as possible.

have been widely misinterpreted as a warning against further commitments to nuclear energy anywhere. Study of the report shows that the warning was intended to apply to the U.K.'s proposed large-scale introduction of fast reactors, e.g.,

Our concern here is not with the position at present or even in the next decade, but with what it might become within the next fifty years.

The U.K.'s proposed program for fast reactors involved the separation of relatively large amounts of plutonium from used fuel at one location, then its transportation some hundreds of kilometres for fabrication into new fuel assemblies at another location. The technology would be exploited commercially by offering the separation and fabrication services to foreign countries, with the separated plutonium product being shipped around the world. The perceived vulnerability to

accidents and accessibility to illegal diversion of a very hazardous material caused many people to oppose introduction of "the plutonium economy".

In Canada, critics illogically equated "the plutonium economy" to recycling fuel from CANDU reactors, then being discussed as a research project. For this, however, it is not essential to separate the plutonium and, even if this were done, it would probably be done in an integrated separation/fabrication plant, obviating the need for transportation of the separated product.

This distinction is important in understanding the Canadian debate over the Flowers Report's attitude to nuclear wastes. The critics cited:

[There should] be no commitment to a large programme of nuclear fission power until it has been demonstrated beyond reasonable doubt that a method exists to ensure the safe containment of long-lived, highly radioactive waste for the indefinite future.

The proponents responded with:

We are confident that an acceptable solution will be found and we attach great importance to the search. . . . There are two reasonable options for the permanent disposal of vitrified high level wastes: to geological formations on land and below the ocean bed. . . . The costs of sound waste management practices are unlikely to add appreciably to the costs of electricity generated from nuclear power.

But the critics came back with:

But neither of these [disposal options] has been sufficiently studied nor demonstrated as a feasible option. . . . In view of the long lead times that will almost certainly be involved in the development of appropriate disposal facilities, we are convinced that a much more urgent approach is needed.

A Canadian academic, Professor Robert Uffen, conducted a study of the significance of the report for Ontario Hydro. He simply prorated the installed nuclear capacity in the two countries to arrive at the conclusion that, for Canada, 20 GWe would constitute the "large programme" beyond which Flowers recommended no further commitment without a waste-disposal demonstration. He apparently ignored the fact that the Flowers Commission was warning against the consequences of a step-change in the nature of the U.K.'s program, not just a quantitative change in an existing program that it considered acceptable.

Finally, the commissioners exhibited remarkable insight into the causes of opposition to nuclear energy:

Nuclear power has in some ways become the whipping boy for technological development as a whole. . . . Nuclear power provides a dramatic focus for opposition in some countries to technological development and we have no doubt that some who attack it are primarily motivated by antipathy to the basic nature of industrial society, and see in nuclear power an opportunity to attack that society where it seems likely to be most vulnerable, in energy supply.

Unfortunately, the same antipathy and the same opposition are apparent today, in Canada and elsewhere.

2.2 The Windscale Inquiry, 1978 (Mr. Justice Parker)

The next U.K. inquiry was much more restricted in scope, viz., to determine whether a new plant to separate plutonium from used fuel, mostly for use in fast reactors, should be built at Windscale. A High Court Judge, Mr. Justice Parker, was appointed "Inspector" and he was assisted by two "Assessors" with outstanding technical qualifications.

In public hearings, opposition focused on claims that approval of the plant would increase the risk of nuclear weapons proliferation, would increase vulnerability to terrorism, and would result in losses of civil liberties. Underlying all these was the assumption that plutonium constitutes a unique hazard.

The report distinguished facts about plutonium from some myths surrounding it. Plutonium can be the raw material for nuclear explosives; if breathed, it can be harmful even in very small amounts; and it is very long lasting. However, it is not exclusively man-made. Plutonium was created in the prehistoric natural reactors at Oklo. It is not "the most toxic substance known to man and significant amounts could be eaten without appreciable harm". The transportation risk from a tanker of chlorine, regularly moved by road and rail, is greater than that from a container of used fuel with its plutonium content. Parker specifically rejected the use of the phrase the plutonium economy as being both emotive and inaccurate.

The report recommended, with explicit reasons, that construction of the Windscale plant should be allowed. Some of the reasons were specific to U.K. conditions. Used fuel with steel sheaths could not be stored confidently under water for more than a few years, so that reprocessing is preferable to indefinite storage. The U.K., with no indigenous uranium, should not allow itself to become dependent on foreign supplies and so should recycle used fuel. Since the U.K.'s long-term program for nuclear energy was based on fast reactors that require recovered plutonium, reprocessing plants are necessary. Getting on with the job would permit disposal of the true wastes, which were being stored in ever-increasing amounts.

Reasons with more universal relevance include:

It is necessary to keep the nuclear industry alive and able to expand should expansion be required. Such expansion might be required, either to meet additional energy demands, or to preserve a 'mix' and to avoid over-dependence on a particular energy source, or to reduce the number of fossil fuelled stations . . . more harmful than nuclear stations.

If reprocessing is going to take place at some time it is preferable to start without delay since the techniques can then be developed at a reasonable rate, and greater experience can be gained, both of the process itself and of the behaviour and effects of the emissions involved, whilst spent fuel stocks and arisings are comparatively small. This is to the benefits of workers, public and future generations alike.

In recommending that the Windscale plant should accept foreign fuel, the report put great weight on the nuclear Non-Proliferation Treaty, stressing that it constituted a bargain: "I do not accept that the best way to achieve a new bargain is to break an existing one". Any state denying reprocessing technology and services to another state would be in breach of the treaty. Such denial could encourage the client state to develop its own capacity to produce separated plutonium. The advantages of providing the service would outweigh the disadvantages.

Although the Windscale Inquiry was apparently narrow in scope, the report remains relevant, if only because it shows how someone trained and experienced in making judgements from the evidence available assessed opposing arguments that are still current.

Parker rejected the classical argument, presented by Dr. Alice Stewart, that there should be no decision as long as the experts fail to agree. Acceptance would mean that decisions could be made only in the rare pauses in scientific debate. He went into considerable detail to explain why he found Stewart unconvincing in her claims for the effects of low-level radiation. He considered that bodies such as the ICRP are the proper ones to evaluate her claims, while appropriate national authorities should be the ones to take any action that may be necessary.

Members of the public are sometimes unnecessarily worried when permissible limits are inadvertently exceeded. "In this connection", Parker advised, "it is as well to mention that the dose limits are not intended to set some absolute standard, the exceeding of which will at once result in a dangerous situation".

Parker rejected the suggestion that the U.K.'s regulatory body should be more involved in design. In the first place it may lead to the designers seeking to shed what is properly their responsibility. In the second place an Inspectorate which is too intimately involved can be robbed to an extent of the independent objective judgement which is its function to exercise.

Parker concluded that approval of the plant should not be refused "either on security grounds or on civil liberty grounds". The existence of terrorism and of other "people with evil purposes" might require some restriction of civil liberties, but this would not be the fault of the Windscale plant or be significantly worsened by it.

In a section on "Public Hostility", Parker criticized, with examples, some proponents for overstating the safety case and some of the opponents for their emotive and inaccurate films and books. He stressed that both sides have valid moral arguments. "It was, moreover, abundantly clear on the evidence that some who pursued the moral line had done so without investigating the consequences of pursuing alternatives".

2.3 The Sizewell Inquiry, 1987 (Sir Frank Layfield, Q.C.)

This inquiry was charged with reporting on an application by the U.K. Central Electricity Generating Board (CEGB) to construct the first pressurized-water reactor (PWR) of U.S. design in the U.K., at an existing nuclear station at Sizewell. The inquiry was conducted by an eminent jurist, Sir Frank Layfield, Q.C., as "Inspector", assisted by four "Assessors", or technical experts.

The hearings occupied 340 days over a period of more than two years, with the evidence presented being subject to cross-examination by counsels for the inquiry and for participants on both sides. Transcripts of the hearings ran to 16 million words. The Inquiry's report, published in 1986, consisted of more than one hundred chapters.

The report starts by stating explicitly the CEGB's four major reasons for wishing to construct the Sizewell B station, then the twenty-three main contentions of objectors, grouped under the headings of safety, economics, environment and general policy. The bulk of the report provides the basis for the Inspector's conclusions on these claims and contentions. His primary conclusion was that consent should be granted to the CEGB's proposal, subject to certain conditions, undertakings and recommendations.

Much of the report is specific to U.K. circumstances, particularly those parts concerned with the economic assessment and environmental factors. For the U.K., Sizewell B would probably be cost-saving compared with available alternatives, and the environmental detriment resulting from siting the station in an Area of Outstanding Natural Beauty would probably be justified by the national benefits. The Inspector rejected the claim that electricity-conservation measures would represent a better use of public funds, arguing that both could proceed in parallel, provided that both are cost-effective.

Even the part of the report on reactor safety is not directly relevant to countries, like Canada, that have no reactors of the PWR design. However, there are many findings of general relevance to regulatory programs.

Foremost among these is the emphasis placed on a satisfactory quality assurance program at all stages of the enterprise, and on the importance to safety of human factors. The report endorses the CEGB's reliance on sound engineering judgement, with accident probability analysis used in a supporting role. The Inspector, in his turn, placed "a great deal of reliance on the CEGB and NII [the U.K.'s regulatory agency] to provide continuing assurance of safety," basing his confidence on these bodies' past performance, "the quality of [their] evidence, and the way in which it withstood searching and extensive examination".

A major difficulty for the Inquiry in assessing whether the station would be adequately safe was that "there was no authoritative guidance from the [U.K.] Government or Parliament on what a level of tolerable risk from a new nuclear power station might be, nor on how it should be determined". In this vacuum, the Inspector concluded "that a level of individual risk of death of the order of once in a million years is likely to be broadly tolerable if justified by associated benefits". He estimated that "the social (or collective) risk to members of the public from Sizewell B would result in an average of one death every five hundred years in the UK, and up to one death every eighty years worldwide", and he concluded that "this can be regarded as tolerable."

The report points out that for nuclear energy, as for virtually all other activities, the technical possibilities for increasing safety are almost limitless. Thus judgement must be exercised in determining the expenditures to be devoted to safety. To arrive at this judgement, the report recommends the ALARP (As Low As Reasonably Practicable) principle, incorporating, but not relying exclusively upon, a cost-benefit analysis. In the absence of this proviso, there is a danger of an inexorable increase in safety standards, resulting in a misallocation of national resources between nuclear safety and other worthy causes.

The Inspector did, however, express concern over the occupational risk:

The risks to workers at the station may be higher than risks to workers in most other industries considered to have high standards of safety

and urged application of the ALARP principle to minimize these risks. Doing so, however, he estimated that it would be difficult to justify spending more than, say, \$6 million per life saved to reduce the occupational risk further.

Risk estimates in the report are based on recommendations of the ICRP, which the Inquiry endorsed subject to the warning that an ICRP review would probably increase the numerical value of the risk per unit dose. (This has since occurred, by a factor of about four.) Some objectors, notably Dr. Rosalie Bertell, criticized the composition and recommendations of the ICRP, but these objections were rejected, thus:

Bertell's recommendations for changes to safety criteria for normal operation of nuclear power stations were based on a misunderstanding of the existing criteria, as well as an estimate of the risk of fatal cancer from radiation that was not supported by evidence.

The Inspector considered that concerns expressed over risks associated with the used fuel did not justify his refusing consent to the proposal. Specifically:

The CEGB's conclusion that the safe disposal of all types of radioactive waste was technically feasible was not disputed. . . .

There are no reasons connected with the management of radioactive waste why consent for Sizewell B should be refused. . . .

In comparison with most other safety issues considered in the Report, the safety of spent fuel transport gives extremely little justification for anxiety. . . .

Grant of consent for Sizewell B would not, in my opinion, lead inevitably to a great expansion in the production of plutonium with an attendant need for increased security and potential restriction of civil liberties.

3. UNITED STATES

3.1 Ford-MITRE's Issues & Choices, 1977 (Dr. S.M. Keeny)

The Ford Foundation commissioned the MITRE Corporation to undertake a study "to provide. . . some clarification and perspective on the full range of technological, economic, and public policy issues relating to the domestic and international use of civilian nuclear energy." A study panel of 21 senior individuals, most from universities, was assembled according to the criteria that, individually, they had to be recognized experts in their fields and, collectively, be and be seen to be open-minded on the subject of nuclear energy. The Chairman, Dr. Spurgeon M. Keeny, was Director of Policy and Program Development for the MITRE Corporation.

The size, composition and diversity of the panel was reminiscent of the U.K.'s Royal Commission on Environmental Pollution. Also, the Ford-MITRE report steered a middle course that, at the same time, pleased and displeased both sides of the nuclear debate. It was, however, less ambivalent than the Flowers Report on individual findings. Its overall conclusion was well summarized in a headline of the day: "Nuclear Power Yes, Plutonium No". The panel endorsed nuclear energy in its current form, but recommended indefinite deferral in the introduction of fuel recycling or fast reactors.

On the need for nuclear energy, the panel favoured the low end of the range of estimates for electricity demand. However, it dismissed some of the near-theological arguments of the "soft path" advocates thus:

In our view, it is neither necessary nor wise to regard energy as something special, requiring novel intellectual approaches and analytical devices. In human affairs, we are not concerned with energy as a physicist's concept. . . . It is incorrect to argue that nuclear power is "needed" now to allow society to continue its development as it is misguided to hope (or fear) that society could be forced into some no-growth utopia if only the current nuclear program were abandoned.

Energy conservation was endorsed, but with the warning:

We believe that it is unwise, however, to base policy on the assumption that such [lifestyle] changes will occur, and we see no reason to argue that they should occur. Every energy supply system and conservation measure has its difficulties. . . .

Alternative energy sources, such as solar or fusion, could not be expected to make an important contribution until at least well into the next century. A basic conclusion of the panel, therefore, was that the U.S. must depend on a mix of coal and nuclear plants for any major expansion in electrical capacity. Much of the report was concerned with comparisons between the two.

Comparisons of the health and environmental effects and of the economics showed little difference between them, but with nuclear energy slightly better:

The ranges of possible social costs, such as health and environmental impacts, associated with coal and nuclear power also overlap to such an extent that neither has a clear advantage. . . . Despite these large uncertainties, the general conclusion is that on the average new coal-fired power plants meeting new source standards will probably exact a considerably higher cost in life and health than new nuclear plants. . . . Except for local thermal pollution where nuclear power has a somewhat more serious effect, the coal cycle generally has more harmful environmental impacts than the nuclear power cycle. . . . The basic conclusion of this chapter is that, despite large uncertainties, nuclear power will on the average probably be somewhat less costly than coal generated power in most of the United States, or to be more precise, in areas that contain most of the country's population.

The conclusion concerning health impacts was reached after making an upper-limit allowance for the possible consequences of a serious nuclear accident.

The study group did not see waste disposal as a serious impediment to the expansion of nuclear capacity: "We are convinced that nuclear wastes and plutonium can be disposed of permanently in a safe manner."

Much of the report is concerned with the proliferation of nuclear weapons, understandable considering that nearly half the study group participants had had some affiliation with the U.S. Arms Control and Disarmament Agency. The group concluded that nuclear energy as currently practiced did not constitute a serious threat, but expressed concern over proposed plutonium recycling and the introduction of fast reactors:

We would be prepared to recommend stopping nuclear power in the United States if we thought this would prevent further proliferation. However, there are direct routes to nuclear weapons in the absence of nuclear power, and the future of nuclear power is not under the unilateral control of the United States. Most advanced countries are now actively developing and utilizing nuclear power, while less developed countries count it among their expectations. In fact, abandonment of nuclear power by the United States could increase the likelihood of proliferation, since the United States would lose influence over the nature of nuclear power development abroad. . . . The advent of separated plutonium in the nuclear fuel cycle would greatly increase the available technical opportunities for proliferation of nuclear weapons and of theft of weapons materials. The risk arises not only in the existence of the technology, a technology easily developed in most countries, but also in the existence of mixed oxide [uranium and plutonium] fuels which may be stolen or misused. Reprocessing and recycle thus present dangers larger than those presently involved in the LWR uranium fuel cycle where the low-enriched uranium fuel cannot be used for weapons.

The study group did not regard terrorism as a reason for abandoning nuclear energy. In an era when:

weapons of increasing sophistication are available to terrorists, including automatic weapons, modern high explosives, and even rockets and anti-aircraft missiles,

it would take great optimism to believe that terrorists would choose to expend their time, money and even their lives on nuclear means.

The report was widely perceived as being instrumental in terminating two major nuclear projects, the Barnwell reprocessing plant and the Clinch River demonstration fast reactor, because of proliferation concerns. While there is some truth in this, other factors were at least as important.

Both projects had been losing support on purely technical grounds. Reprocessing in the U.S. had had a disastrous history. In the weapons industry, reprocessing had produced large volumes of liquid wastes without any plan for their solidification and disposal, and some of these wastes had leaked to the environment. An early civilian reprocessing plant at West Valley, New York, had performed very poorly, and another, at Morris, Illinois, had been built but never operated. The Barnwell plant, in South Carolina, was overtaken by escalating regulatory requirements as it was being built, so that its estimated costs had become uneconomic. Similarly, the design of the Clinch River fast reactor, frozen several years earlier, had been overtaken by technical developments, so that its operation as a demonstration would have had only marginal value.

The Ford-MITRE study recommended deferral, not rejection, of fast reactors and hence recycling:

The hard question concerns the timetable on which a breeder might have sufficient economic merit, compared with other sources, to outweigh the potentially large social costs associated with a plutonium fuel cycle. . . . Introduction of the breeder may be deferred for ten, twenty, or more years without seriously affecting the economic health or energy security of the United States. . . . It is important to continue work on the breeder, with a longer time horizon and an emphasis on its role as insurance. The goal should be to provide a range of more attractive choices at a series of decision points extending into the early decades of the next century.

In this context, the study group probably intended "breeder" to be synonymous with "fast reactor". Earlier in the report, however, there had appeared:

Since the timetable for the breeder can be relaxed without large economic risks, it is natural to reopen the question of whether alternative converter reactors can still play a role. The present U.S. program does not pay much attention to new converters such as . . . natural uranium reactors like the Canadian CANDU. . . [which] can already obtain 20-40 percent more energy from unenriched uranium. . . . Use of a thorium cycle converter would also tap a new resource base.

The recommended deferral of recycling was based on the questionable assumption that:

More intensive and extensive exploration should produce enough uranium, both in the United States and abroad, to supply the domestic and foreign requirements of the lightwater reactors (LWRs) well into the next century.

One can also read into the report a neo-colonialist attitude that deferral of recycling would allow the U.S., with its near monopoly on uranium enrichment (the only other practical source of separated fissile material), to control the proliferation of nuclear weapons.

A few weeks after the Ford-MITRE report was published, President Carter issued a seven-point statement on nuclear power policy almost identical to seven recommendations in the report. This may have been partly due to the fact that two members of the study group, Harold Brown and Joseph Nye, had meanwhile been appointed to high positions in the Carter administration.

3.2 Workshop on Alternative Energy Systems, 1977 **(Dr. C.L. Wilson)**

In 1974, the Workshop on Alternative Energy Strategies (WAES) was established under the direction of Carroll L. Wilson of the Massachusetts Institute of Technology, as an experiment in international collaboration. The objective was to assess global energy supply and demand prospects to the end of the century.

The workshop consisted of 30 full participants (assisted by working associates) drawn from 15 industrialized countries that consumed 80% of the world's energy and three major oil-producing countries. However, "each person had to be free to represent his own views rather than those of his organization. Each should bring a wide range of personal experience and a network of national and international relationships that would allow him to communicate the Workshop's findings and their implications for energy policy in his own country and in international forums." Each national team estimated its own country's energy supply and demand. Estimates for non-WAES countries were made by associates familiar with these countries.

The Workshop's conclusions were summarized in "Energy: Global Prospects 1985-2000":

After two years of study we conclude the world oil production is likely to level off — perhaps as early as 1985 — and that alternative fuels will have to meet growing energy demands. Large investments and long lead times are required to produce these fuels on a scale large enough to fill the prospective shortage of oil, the fuel that now furnishes most of the world's energy. The task for the world will be to manage a transition from dependence on oil to greater reliance on other fossil fuels, nuclear energy, and, later, renewable energy systems.

The Workshop forecast that the demand for energy would continue to grow even if governments adopted vigorous conservation policies. Specific conclusions called for improved energy efficiency, increased exploitation of coal and natural gas, substitution of electricity for oil, and the use of nuclear energy as an important contributor to this electricity.

3.3 Committee on Nuclear and Alternative Energy Systems, 1979 (Drs. H. Brooks and E.L. Ginzton)

In 1979, the U.S. National Academy of Sciences finally published the results of a study by the Committee on Nuclear and Alternative Energy Systems (CONAES) that had been requested four years earlier by the Government's Energy Research and Development Administration. The committee proper was dominated by academics, but it included five senior executives from industry. Reporting to the committee were four panels, each of which established working groups. These were assisted by a staff of 13 and 36 consultants or contributors. In all, some 350 individuals contributed to various aspects of the study.

The principal conclusions of the 783-page report, "Energy in Transition, 1985-2010", are clear and simple. The U.S.'s most critical energy problem is the availability of fluid fuels, and energy conservation is the most important response. However, the wide diversity of input to the study is reflected in the 100% overruns in the budget and schedule, in the ambidexterity of some of the conclusions ("on the one hand this, on the other hand that"), and in the many dissenting statements. As a result, both proponents and opponents of nuclear energy have found things to praise and to criticize in the report.

Nuclear opponents use the report's conclusion that it is technically feasible for the U.S. to provide a higher level of amenities in 2010 with no more energy than at present to argue that nuclear energy is unnecessary. Proponents counter that it was not the feasibility that was challenged, but the likelihood and desirability. Opponents claim that this can be achieved without serious social disruptions. Proponents point out that this scenario assumes low growth in the economy (3% per year decreasing to 1%), energy taxes, migration of populations to the "sun-belt" states, and "aggressive, coordinated long-term policy actions in the areas of land use, transportation and electric utility regulation". To obtain improved energy efficiency, the then current air-pollution standards would not be tightened.

The report concluded that solar energy, and other renewable energy sources except hydroelectricity, would make only a very small contribution.

The depletion of fluid fuels should be compensated by increased exploration and recovery of conventional oil, the production of synthetic fuels, particularly from coal, and by substituting electricity for oil. This study, like the earlier Ford-MITRE one, proposed that the increased electrical capacity should be roughly equally split between coal-fired and nuclear stations.

The committee was divided on nuclear energy between those who regarded it as highly attractive and those who viewed it as a "necessary evil" to be accepted only as a transitional source. Nuclear proponents were encouraged by the CONAES conclusions that national policy should support the continued use of nuclear energy for the next few decades; that "on safety grounds alone, the expansion of nuclear power would be acceptable; that the short-term health risks from routine operation of the . . . nuclear fuel cycle appear to be far below the risks from the coal fuel cycle, that no insurmountable technical obstacles are foreseen to preclude safe disposal of nuclear wastes in geological formations;" and that "nuclear power is not the most likely route countries with the will to acquire nuclear armaments might follow." Opponents noted that these conclusions were qualified, and subject to dissenting opinions, and that the committee had warned of a possible uranium shortage and had criticized some aspects of wastes management.

While the study was under way, a major issue was the future of the U.S.'s program for fast-breeder reactors, with associated fuel reprocessing. The CONAES Report pleased nuclear proponents by recommending continued research and development, and pleased opponents by recommending against immediate deployment. To complement the development of fast-breeder reactors, the report recommended development, to the point of evaluation, of advanced reactor types, including advanced versions of heavy-water reactors. It specifically noted that "the advanced converter [reactor] most widely used in the world is the natural-uranium, heavy water CANDU, developed in Canada."

4. AUSTRALIA

4.1 The Ranger Uranium Mining Environmental Inquiry, 1976 (Mr. Justice Fox)

This inquiry was charged to inquire into all environmental aspects of a proposal to mine uranium from major deposits of the Ranger Uranium Mines Pty. Ltd. in a remote area of northern Australia. The composition of the Commission was very similar to that for the Windscale Inquiry — a Presiding Commissioner, Mr. Justice Fox of the Supreme Court, assisted by two very experienced experts, one an engineer and the other a medical professor. In this case, however, these two were Commissioners and not Assessors only advising the Inspector.

The Commission reported its findings and recommendations in two separate reports. The first, published in 1976, dealt with generic issues related to the questions of whether Australia should exploit and export its uranium resources. Since the answers were affirmative, but conditional, the second, published in 1977, spelled out the conditions in over a hundred detailed recommendations.

Mr. Justice Fox, like Mr. Justice Parker, made judgements from the evidence available. Many of these gave comfort to nuclear proponents, viz.:

The hazards of mining and milling uranium (and similarly for the operation of nuclear power reactors), if those activities are properly regulated and controlled, are not such as to justify a decision not to develop Australian uranium mines. . . .

Although some studies have demonstrated the possibility that acceptable levels of economic activity may be achieved without substantial growth in electricity supplies, it appears that most countries expect their consumption of energy to increase in future, provided growth in economic activity also occurs. . . .

While the operations of the nuclear power industry need close regulation and constant surveillance, they probably do not entail risks greater in sum than those inherent in alternative energy industries.

Nuclear critics, exemplified by the Friends of the Earth, praised the Commissioners for being "magisterially fair in their collection of evidence and in their dealings with the multitude of participants in the hearings" and the report for being "level-headed, methodical and unhysterical". However, they stressed that the Commissioners did not recommend a go-ahead. They merely asserted that there was no reason not to go ahead. Furthermore, they would impose many conditions.

The judgements favoured by the critics relate to concern over weapons proliferation, including:

The nuclear industry is unintentionally contributing to an increased risk of nuclear war. This is the most serious hazard associated with the industry.

However, the Commissioners did not, for this reason, recommend banning nuclear energy. Rather, they recommended strengthening the national and international arrangements to prevent proliferation, particularly the nuclear Non-Proliferation Treaty and associated safeguards, e.g.:

We believe it both essential and possible to make safeguards arrangements more effective. . . . Stringent safeguards provisions in sale agreements would also assist in minimising the risk that any uranium exported by us to them will be used for any military purpose. . . . It may be that by supplying some countries we would help to relieve those pressures which can lead to armed conflict, nuclear or non-nuclear.

A judgement receiving limited approval from both proponents and critics was:

While we do not think that the waste situation is at present such as to justify Australia wholly refusing to export uranium, it is plain that the situation demands careful watching, and, depending on developments, regular and frequent reassessment.

4.2 Australia's Role in the Nuclear Fuel Cycle, 1984 (Professor R.O. Slayter)

In 1983, when the Australian Labour Party Government was faced with active opposition to its policy of mining and exporting uranium, particularly from its own left wing and unions, it requested the Australian Science and Technology Council (ASTEC) to examine the relevant issues. The 18-person Council, predominantly drawn from the upper ranks of the universities and industry, was chaired by Biology Professor R.O. Slayter. Thus the composition of this inquiry was more similar to that of the Flowers Commission than of the Parker or Fox Inquiries.

The report is similarly reminiscent of the Flowers Report. It constitutes an excellent source-book on the basics of nuclear energy, national nuclear programs and their reactor designs, all aspects of the nuclear fuel cycle (especially the management of wastes), and factors affecting the proliferation of nuclear weapons. The report, whose stated purpose "is to examine Australia's role in the nuclear fuel cycle", is summarized in 28 pages, with 30 succinctly worded and high-lighted recommendations. However, there are no summarized conclusions, and any explicit judgements are rare, so that many of the Council's judgements have to be inferred.

The report's major recommendation, implying an overall endorsement of nuclear energy, states:

That exports of Australian uranium should not be limited as a matter of principle subject to stringent conditions of supply designed to strengthen the non-proliferation regime.

The ASTEC report reaffirms much of what was said in the Fox report. On global energy supply:

Reliable supplies of energy are vital for the economic development and social stability of modern societies. The more industrialised the society the greater is the dependence on energy. An increasing fraction of the total energy used is provided by electricity. . . . The fraction of electricity generated by nuclear energy is growing rapidly. . . . There have also been increasing concerns about the environmental effects of coal-fired power plants in particular and fossil-fuel fired plants in general. If international tensions are to be reduced and the prospects of a peaceful global environment enhanced, the importance of national and international energy security cannot be over-emphasised. . . . Through being a reliable long term supplier of uranium, Australia is in a position to contribute significantly to international energy security.

The report summarizes the situation on health protection thus:

A highly developed, systematic approach to limiting the exposures of people to radiation from nuclear activities has evolved over the last 30 years. Radiation protection standards are established which set limits on exposures which are not to be exceeded. . . . The basic issues of radiation protection, its standards and their implementation are under constant review by expert international bodies.

The absence of any recommendation in this area implied satisfaction with the existing situation.

Similarly, the ASTEC report implied endorsement of the existing requirements for control and monitoring of uranium mining and milling wastes by recommending only that these requirements be reviewed regularly, incorporated in appropriate regulations and monitored for observance.

On the subject of the disposal of used-fuel wastes, the Council, some of whose members visited Canada among other countries, found:

Although a complete demonstration of all aspects of the multiple barrier system has not yet been carried out, there is a widespread consensus amongst scientists working in the field of radioactive waste management that the fundamental geological, chemical and physical principles are adequately understood. In consequence, there is general agreement that the multiple barrier approach is capable of preventing the release of radionuclides to the biosphere for sufficient time and restricting their release to such low levels that they do not present a significant health hazard either to the population at large or to the potentially most exposed individuals, far into the future. . . . Spent fuel encapsulation, vitrification and advanced waste forms all appear likely to be satisfactory methods to contain and immobilise high level radioactive waste. . . . We consider that there are no insurmountable technical problems in construction of a suitable mined repository in several different types of rock, although some appear preferable to others. . . . There appear to be no economic factors which would seriously constrain safe disposal methods for high level wastes. . . . We consider, moreover, that the technology required to achieve these objectives is available.

However, nuclear proponents would question the logic of ASTEC's resulting recommendation:

That Australia not seek to impose particular strategies for radioactive waste management on countries using Australian uranium but rather encourage all countries to adopt the best practicable, rather than merely adequate, waste management strategies. [Emphasis added.]

Making any technology much safer than others, by using limited resources, can only decrease overall safety for society.

Most of the ASTEC report is concerned with preventing the spread of nuclear weapons, a matter on which the Fox report sounded a warning. The ASTEC recommendations implicitly reaffirm Fox's support for the nuclear Non-Proliferation Treaty and the International Atomic Energy Agency, by suggesting how Australia could contribute to their strengthening and general improvement. Specifically, ASTEC identified the technology and equipment for enrichment and reprocessing as the key requirements for a weapons program, so that these deserved greatest attention. Thus:

An important objective is therefore to develop institutional systems to increase the control on enrichment and reprocessing plants so that their development in non-nuclear weapon states will not weaken the non-proliferation regime.

With respect to mining uranium for power reactors, it concluded:

There is no shortage of uranium in the world. . . . A country would therefore be able to develop a weapons program irrespective of whether or not there was an international trade in uranium for civil nuclear purposes. . . . Should a country decide to embark on a weapons program it is unlikely to use a civil power reactor to do so. This is because such a use would be inefficient both in terms of producing weapons usable material and in terms of electricity generation. . . . [Power reactors could be misused]. . . however, it is important not to impugn the motives of countries which have adopted nuclear power programs for well justified reasons of energy supply and energy security and which have accepted safeguards on their nuclear facilities.

5. NEW ZEALAND

5.1 Nuclear Power Generation in New Zealand, 1978 (Sir Thaddeus McCarthy)

In 1976, the New Zealand government established a five-person Commission, chaired by the Right Honourable Sir Thaddeus McCarthy, to inquire into the prospects of nuclear energy for New Zealand. The Commission invited both official and public submissions, and visited many nuclear-related facilities around the world, including some in Canada.

The Commission's principal conclusion was:

There is no satisfactory case for New Zealand to immediately commit itself to a nuclear power programme. On present evidence it appears to have sufficient indigenous resources to enable it to meet its reasonably projected needs for electricity into the next century. . . . Hydro, geothermal and indigenous coal are estimated to be more economic than nuclear for New Zealand conditions. . . . New Zealand should aim to rely on its own resources for electricity as long as it is economically and environmentally sensible to do so. . . .

However, it warned:

The development and use of indigenous resources to postpone a decision on nuclear power will call for resolution, for substantial allocations of money and manpower, and for the acceptance of some environmental impacts. . . . [To] do without nuclear power. . . the people of this country will have to accept the environmental consequences of enlarged programmes of hydro, geothermal, and coal development.

The Commission therefore proceeded to examine the conditions under which nuclear energy might be needed, and whether it would be acceptable.

On the need for nuclear energy, the commission reported:

The officials and engineers responsible for delivering electricity to the nations we visited were almost unanimous that nuclear power was a necessary and irreplaceable source of the future energy for mankind in the short and in the longer term.

For New Zealand, it considered that nuclear energy would be required sometime in the future, along with conservation and other energy resources, both renewable and non-renewable, and dismissed as unrealistic the "soft path" advocated by some nuclear critics. It concluded:

The chances of New Zealand needing nuclear power for electricity generation early in the next century are real indeed, and a significant nuclear programme should then be economically possible, if a similar relationship to that which in the past has existed between economic and electricity growths is maintained.

The Commission recommended one serious proviso on the acceptability of nuclear energy:

New Zealand should not embark on a nuclear power programme until suitable arrangements for the disposal of all high-level radioactive wastes from any proposed nuclear stations have been convincingly demonstrated.

However, it considered that waste-disposal problems would be solved. Furthermore, it examined and rejected arguments that nuclear energy would be unacceptable because of considerations of the health effects of routine emissions from generating stations, of reactor accidents, weapons proliferation, terrorism, and social measures to prevent terrorism.

On ethical aspects of the debate, the Commission considered:

There is a moral duty to posterity to hand on as many developed energy producing technologies as possible. . . . Some critics have seen nuclear power as a focal point for discussing the wider issues of energy production and consumption and their effects on society.

6. ***INTERNATIONAL***

6.1 ***International Nuclear Fuel Cycle Evaluation (INFCE), 1980***

U.S. President Carter, shortly after his election towards the end of 1976, issued a statement on nuclear power policy. (For background, see Section 3.1 on the Ford-MITRE study.) In it he identified the problem as one of preventing the proliferation of a nuclear-weapons capability without foregoing the "tangible benefits of nuclear power". He proposed seven measures to achieve this objective.

Four measures concerned U.S. domestic policy — deferring indefinitely commercial reprocessing and the commercial use of fast-breeder reactors, restructuring the research program to seek fuel cycles more resistant to proliferation, and increasing the capacity for uranium enrichment. However, two measures affected other countries and in some instances involved the abrogation of existing agreements — ensuring a virtual U.S. monopoly on the international supply of enriched uranium and embargoing the export of technologies for uranium enrichment and fuel reprocessing.

Understandably, there was considerable international resentment to Carter's proposals. The U.S., with its abundant energy resources, could afford a uranium-wasteful fuel cycle and deferral of fuel recycling, but most countries were not so fortunate. The continuing monopoly on enriched uranium would allow the U.S. to threaten a country with the shutdown of its electricity supply in furtherance of U.S. policies far beyond nuclear non-proliferation. The denial of exports was seen as a unilateral contravention of the U.N.'s nuclear Non-Proliferation Treaty, whereby the U.S. and other nuclear-advanced countries promised to help less advanced countries enjoy the benefits of nuclear energy in exchange for a promise not to make or acquire nuclear weapons.

The international opposition was anticipated in Carter's seventh measure: a proposal to establish "an international nuclear fuel cycle evaluation program aimed at developing alternative fuel cycles and a variety of international and U.S. measures to assure access to nuclear fuel supplies and spent fuel storage for nations sharing common nonproliferation objectives." Many saw this as little more than an expedient to postpone confrontation — the international equivalent of a Royal Commission — but the International Nuclear Fuel Cycle Evaluation (INFCE) was established at a conference of 40 countries and four international agencies in Washington in October of 1977.

Despite considerable political input at the coordinating level, INFCE was largely a technical study that occupied over two years and resulted in a final report consisting of a set of nine documents supported by a depository of hundreds of national reports. In summary, INFCE made some concessions to the U.S.'s concerns over weapons proliferation, but reasserted the world's need for nuclear energy with an assured fuel supply. Consensus was reached on the best compromise to achieve both objectives.

INFCE's detailed findings were:

- Nuclear energy is expected to increase its role in meeting the world's energy needs over the next half century.
- Nuclear energy can play a significant role in helping to supply energy at reasonable cost in many developing countries. Generally, these countries need arrangements of broad scope covering supply of equipment and materials, training of appropriate manpower, participation of domestic industry, research cooperation and financing, all with assurances of long-term stability.

- On a global scale, additional sources of uranium production supported by new discoveries will be needed before the end of the century.
- Uranium-conserving strategies will be needed. Potential improvements in once-through fuelling for currently commercial reactors could result in uranium savings up to 30 per cent, but substantially greater savings would require fuel recycling.
- Since considerations of economics and energy strategy vary from country to country, no one fuel cycle will be the economic choice everywhere.
- While the safety of the various fuel cycles can be assured by the strict application of regulations, sociological aspects will vary between countries, depending on their national requirements and priorities.
- Long-term assurances of supply of nuclear materials are very important. The commercial market is the major instrument for this, and possible improvements in it were identified.
- International agreement on the non-proliferation conditions imposed by supplier countries is desirable.
- Although technical measures can relieve proliferation concerns, proliferation is primarily a political matter.
- No single judgement about the risk of proliferation from the different fuel cycles can be made that would be valid for the foreseeable future.
- Phases of the fuel cycle that are sensitive to proliferation concerns are: fresh fuel containing enriched uranium or plutonium, uranium-enrichment plants, reactors, used-fuel storage, fuel reprocessing, plutonium storage, fabrication of plutonium-containing fuels, and used-fuel disposal.
- While it should prove possible to develop safeguards against proliferation through enrichment plants, limiting the number of such plants to that necessary to supply the market is desirable from the perspective of non-proliferation.
- In general, the phase during which the fuel elements are in an operating reactor is less important to proliferation than other phases of the fuel cycle.
- The most sensitive aspects of fuel recycling depend on the threat:
 - for subnational theft, transportation,
 - for overt diversion by government, plutonium storage, and
 - for covert diversion by government, reprocessing and fabrication plants.

Protection against the threats requires technical and institutional measures:

- The high radiation level inherent in used fuel is an important factor against diversion from used-fuel storage.
- Provided that the repository for final disposal of used fuel is designed for irretrievability, even cursory surveillance would ensure timely detection of attempts at diversion.
- Measures to minimize the danger of misuse of fuel-cycle facilities include, in order of increasing importance, technical measures, institutional arrangements and safeguards systems.

- Most research reactors using highly enriched uranium could be converted to use lower fuel enrichments, with a consequent improvement in resistance to diversion.

6.2 World Energy Council (formerly World Energy Conference), 1989

The World Energy Council (WEC) is a nongovernmental organization that carries out studies and convenes major congresses, normally every three years. The Fourteenth Congress, held in Montreal in 1989, concentrated on the interactions between energy and society, the environment, the economy and technology. The WEC represents 87 countries, while representatives of approximately 100 countries attended the Montreal Congress.

The Montreal WEC Congress did not produce a consensus report, but the published proceedings include a paper "Conclusions of 14th World Energy Congress" by the Chairman of the Programme Committee, W. Kenneth Davis, former U.S. Deputy Secretary of Energy.

He considered that the information presented at the Congress had shown that "the energy resource base is not a basic problem in the foreseeable future" and that "oil will continue to be the dominant energy resource throughout the first half of the 21st century." There was confidence that supplies of oil, from both conventional and non-conventional sources, natural gas, uranium and coal would prove adequate. With respect to alternative and renewable energy resources:

It must be recognized from a realistic point of view that alternate [sic] and renewable energy sources are not likely to provide a major part of the world's future energy requirements in the foreseeable future except for hydroelectric power which is likely to play a major role in some areas although the potential has largely been exploited in others. It must also be recognized that not all alternate and renewable energy sources are environmentally benign either in the short or long term.

The hope for "magic solutions" from energy research and development is no longer regarded as a realistic prospect.

According to Davis, the Congress concluded that improved energy efficiency could not be relied on to make new energy supplies unnecessary.

Energy efficiency or "conservation" is an important issue. It is necessary to be realistic about it inasmuch as few subjects have been or are the object of as much wishful thinking. Energy efficiency/conservation is being widely promoted as the complete and obvious solution to the environmental and potential global warming problems as well as to the long-term availability of energy resources. While there is no doubt that there are substantial further improvements in energy efficiency which can be achieved on an economic basis, and that these can contribute to the alleviation of the environmental problems, these possibilities must be kept in a real world perspective. The potential impact on the economies of the world and the various countries, especially the developing countries must be taken into consideration.

Where conservation is achieved by increased real price — the principal proven means — it can result in a higher total cost with a consequent adverse effect on the economy.

The environmental effects of energy was the subject most discussed at the Congress, with global warming attracting most attention. There was substantial support for internalizing the environmental costs in the price of energy supplies, but only if the income from the fees or taxes is specifically devoted to meeting these costs. Many of the environmental laws and regulations are seen as both arbitrary and unrealistic. Rational assessments based on cost/benefit analyses are needed if adverse economic consequences are to be avoided.

The special role of electricity as an energy carrier was highlighted at the Congress:

While total energy use in the industrialized countries is growing slowly the use of electricity has increased steadily due to its convenience and efficiency for a variety of tasks. Electricity has become the lifeblood of both developing and industrialized societies.

One estimate suggested that "the developing world will need approximately one trillion dollars to meet their electric power needs over the next decade." The potential contribution to the electricity demand from nuclear energy was summarized:

It is anticipated by most, but not all, observers that as the electricity demand continues to grow in the industrialized countries nuclear power increasingly will be recognized as an essential means of producing economic and safe electric power. This view has received significant impetus from concern about the potential global warming because of the negligible emissions of CO₂ from the overall nuclear cycle.

However, Davis pointed out some of the difficulties of introducing nuclear power into developing countries and warned:

The worldwide problems with adverse public opinion on nuclear power need to be addressed by all. The lack of understanding of the available information as well as a feeling that there is no reason to take any additional risks, however small, unless there is a need to do so — a need now becoming evident in the U.S., the U.S.S.R. and elsewhere — remains an obstruction to its orderly development.

On nuclear safety, Lord Marshall of Goring, former Chairman of the U.K.'s major electricity utility, said:

For the public at large the risk [from a reactor accident] is to all intents and purposes zero. The scientific and technical means of doing that exist. The technical task of doing that is not difficult. The overwhelming task to maintain that level of safety is the institutional task of maintaining the management of the nuclear power stations at the highest possible level. It is only good management that can eliminate human error and it is only constant attention to detail and the wish to improve that produces good management.

The major challenge identified by the WEC for the 1990s is resolving the triple-E problem: concurrently optimizing energy, the environment and the economy. There was a general consensus that the necessary technologies are in relatively good shape and that:

the many problems which face energy and society today will not be solved by technological gimmicks but by cooperative efforts to solve institutional problems.

These include: population growth; financing expensive projects; North/South disparities and debts; the role of public opinion and how media treatment affects it; and, above all, the need to make and implement decisions nationally, regionally and internationally.

7. CANADA

7.1 Parliamentary Committee on Operations of the Atomic Energy Control Board, 1949 (Mr. G.J. McIlraith, M.P.)

An all-party Special Committee, chaired by Mr. G.J. McIlraith, was appointed in 1949 to examine the Atomic Energy Control Board's activities, which then consisted largely of the atomic energy project at Chalk River. After six public sittings, several meetings in camera and a visit to Chalk River, over a six-week period, the Committee produced its report. It concluded that "the atomic energy project at Chalk River is well and efficiently run, and that the Canadian activity is in the forefront of atomic research. . . . For Canada to continue in the forefront in this field, it will be necessary to press forward the work with vigour. Your Committee recommends the expansion and development of the project as required from time to time. . . ."

7.2 Parliamentary Committee on the Operations of the Government in the Field of Atomic Energy, 1953 (Mr. G.J. McIlraith, M.P.)

As the result of one of the recommendations of the 1949 Parliamentary Committee, another Special Committee was appointed in 1953 to further study atomic energy in Canada. Mr. McIlraith was again the Chairman. In 1952, Atomic Energy of Canada Limited (AECL), with a mandate to develop atomic energy for the benefit of Canadians, had been established as a separate Crown Corporation independent of the Atomic Energy Control Board (AECB). AECL was then responsible for the Chalk River Project and the sale of radioisotopes. The committee held ten public sittings and visited Chalk River and two other government establishments relevant to atomic energy.

The Committee's main finding was that "the program in the field of Atomic Energy is well integrated and [the Committee] finds that the various parts of the program are well managed and conducted." Among several detailed conclusions was one on Atomic Power:

From the evidence it is clear that the large-scale application of atomic power is closer at hand than had been expected when the previous Committee met. Your Committee notes with interest and approval that the Board of Directors of Atomic Energy of Canada Limited has on it several persons with an intimate knowledge of development, distribution, and economics of industrial power. Your Committee recommends that any possible development of atomic energy for industrial power be pressed forward with vigour.

7.3 Parliamentary Committee on Research, 1956 (Mr. G.J. McIlraith, M.P.)

In 1956, a Special Committee (Chairman Mr. McIlraith) was appointed to examine non-military research in Canada, with specific reference to operations in the field of atomic energy and of the National Research Council.

With respect to atomic energy, the Committee concluded:

Your Committee is in accord with the policies being followed in the field of atomic energy research and commends the work being done by Atomic Energy of Canada Limited and by Eldorado Mining and Refining Limited. Your Committee expresses the hope that Atomic Energy of Canada Limited will press forward its work in the development of atomic energy as a source of power and that it will provide such co-operation as the circumstances warrant, for the purpose of adding to the power resources of Canada.

7.4 Parliamentary Committee on Research, 1960
(Mr. J.W. Murphy, M.P.)

A Select Committee (Chairman Mr. J.W. Murphy) was appointed in 1960 to consider the activities of the National Research Council, Atomic Energy of Canada Limited and Eldorado Mining and Refining Limited. The Committee devoted only one day to AECL and deferred any substantive conclusions on it to the next session.

7.5 Parliamentary Committee on Research, 1961
(Mr. J.W. Murphy, M.P.)

In 1961, the 1960 Select Committee was reconstituted with the same Chairman, but with some change in membership. During the session, the Committee held nineteen meetings in its consideration of AECL's activities, and recorded more than 650 pages of evidence.

Among the Committee's many conclusions and recommendations, the more significant were:

Your Committee commends Atomic Energy of Canada Limited for its vigorous leadership in developing the resources of Canada toward the peaceful use of atomic energy. . . .

Planning and development in the use of nuclear energy for power has proceeded on a schedule that will ensure that when this country's economy and industries require additional power, it will be available. . . .

The Committee believes that AECL has been following a sound and logical course in the development of natural uranium, heavy water type reactors in Canada. . . .

The completion of the Canada-India Reactor was welcomed and the leadership and activity of Atomic Energy of Canada Limited in this project is now apparent. . . .

With respect to the problems of radioactive waste disposal and the safety of reactors, your Committee expresses concern. The Committee commends the careful procedures of AECL in the disposal of radioactive waste materials, but views with concern the absence of any international agreement on this subject. . . .

The Committee approves the practice of the Atomic Energy Control Board in insisting that all reactors be designed in accordance with recognized engineering standards and practices. . . .

7.6 Ontario Royal Commission on the Health and Safety of Workers in the Mines, 1976 (Dr. J.M. Ham)

In 1974, the Government of Ontario established the Royal Commission on the Health and Safety of Workers in the Mines, with Professor James Ham as Chairman and sole Commissioner. He was assisted by a Counsel, a Medical Consultant, an Executive Secretary and Labour, Engineering and Industrial Advisors.

The Commission's terms of reference were broad, with no specific reference to uranium. In the event, however, about half the 5,600 pages of transcripts for the hearings, two of the four commissioned studies, and 23 of the recommendations concerned uranium. The Commission's report, published in 1976, constituted a landmark in defining the health hazards of uranium mining and provided means of reducing these hazards to acceptable levels.

The study confirmed that uranium mining was a hazardous occupation: the fatalities per million man-hours for all underground mining were only slightly less than those for logging, and more than ten times the average for manufacturing. Specifically for uranium miners, some excess deaths over those expected for the general population were due to lung cancers that could be attributed, in whole or in part, to radon in the mines. It appeared that cigarette smoking and possibly diesel fumes were contributing factors to the cancer incidence. However, the major hazard for uranium miners remained that which is common to all underground miners:

In aggregate the deprivation of life years by excessive fatal accidents was *eight times* that resulting from the excess of lung cancer deaths.

Most of the Commission's detailed recommendations were implemented by the Government of Ontario, or the AECB, as appropriate. Although none of these specified permissible numerical limits for miners' exposures to radiation, one consequence of their implementation has been a dramatic reduction in these exposures, largely through improved ventilation of the mines.

7.7 The Management of Canada's Nuclear Wastes, 1977 (Dr. F.K. Hare)

In 1977, the federal Department of Energy, Mines and Resources (EMR), as part of its assessment of the potential contribution of nuclear energy to the national energy supply, established "an independent expert group" to advise on nuclear-waste disposal. The group consisted of three individuals, two of whom had been senior officials of EMR and AECL, respectively; the Chairman, Professor F.K. Hare, a renowned climatologist, had served for a period as a senior official in the Department of the Environment.

The purpose of the study was twofold:

- to review and summarize the current situation, for the benefit of both the government and the public, and
- to make recommendations that could form the basis for government policy.

Because of the short time assigned to the study (about three months), much of the group's activities was devoted to assessing information and programs already developed by other bodies, both in Canada and elsewhere.

The group's report provided a convenient summary of the nature of the nuclear wastes, of their potential health and environmental impacts, of current methods for managing them, of proposed methods for their final disposal, and of Canadian and international programs to develop these disposal methods.

The report's primary recommendation was that a comprehensive national plan for the management and disposal of all nuclear wastes, including those from mining and refining, should be developed. The government responded partly to this recommendation in 1978 with the Canada-Ontario Agreement on a Radioactive Waste Management Program dealing with the wastes from nuclear power reactors.

Nineteen specific conclusions and recommendations included:

There are good prospects for the safe, permanent disposal of reactor wastes and irradiated fuel, and we see no reason why the disposal problem need delay the country's nuclear power program, provided that the government proceeds immediately to the program of research and development in [these] recommendations.

Of the various options for the disposal of reactor wastes and irradiated fuel, we consider underground disposal in geological formations to be the most promising within Canada. Igneous rocks are preferred and two sites within differing igneous rocks should be investigated. . . .

The overall Canadian program of research and development is well conceived, but has received much too little financial support and priority. A large increase will be needed in the scale of geological, geophysical, geochemical and engineering research directed towards the investigation of disposal sites and the task of rendering them operational as repositories. [Aspects requiring greater attention were identified.]

We expect no environmental or health impacts once the wastes and irradiated fuel have been emplaced in the repository. The slight risks will be associated with the preparation, transportation and emplacement functions. . . .

The theft of a significant quantity of irradiated fuel is extremely unlikely.

7.8 Cluff Lake Board of Inquiry, 1978 (Mr. Justice Bayda)

The Saskatchewan government appointed a three-person Board of Inquiry, chaired by Mr. Justice E.D. Bayda, to advise whether a uranium mine and mill proposed by Amok Limited for a Cluff Lake site should be allowed to proceed, and under what conditions. As a result of the Board's report, the government gave the go-ahead to Amok's proposal, subject to certain provisions to safeguard the health and safety of the workers and to provide employment opportunities for northerners; in a more general sense, they agreed in principle with the expansion of uranium mining and milling in Saskatchewan.

The Board held preliminary hearings in order to set rules for the conduct of the inquiry, which were published before further proceedings were undertaken. There were separate rules for formal hearings, local hearings and written briefs. In this way, the Board encouraged public participation at the local hearings while still keeping control of a disciplined and structured procedure for the formal hearings.

The major inputs to the Board's study consisted of an environmental assessment and safety report prepared on behalf of Amok, and a series of hearings. In the formal hearings there was cross-examination under oath by the Board's counsel and by counsels for several of the inquiry's fulltime participants. All the resulting material was publicly available and some of the Board's resources were devoted to improving knowledge of the subject in Saskatchewan.

In practice, the Board interpreted its terms of reference very broadly, and its 429-page report reflected this in covering most of the issues in the nuclear debate. The report is well organized and its value is enhanced by the fact that the authors not only give their judgement on the issues, but explain their reasons. The authors approached their task by first formulating a series of specific questions, which were later answered in the conclusions.

On the need for nuclear energy, the Board found:

We assured ourselves that nuclear power is necessary together with all kinds of renewable and non-renewable energy to supply the world's demand for energy because there is the spiralling effect of projected population growth, the need for much greater energy and mineral resources to increase agricultural production, the need for more energy resources to secure those resources from more inaccessible locations, the need for more energy to control pollution, and the need for more energy to provide those conditions of nutrition, sanitation, and education which make the global community a better place for all to live.

Concerning potential health effects, the Board concluded:

The requirements of Canadian and Saskatchewan law, from the standpoint of the standards they fix, respecting the maximum permissible doses of ionizing radiation and maximum permissible exposures to radon daughters for radiation workers and the population generally, are adequate. . . .

Many of the citizens were not aware that many of these miners [uranium miners who had died of lung cancer] had received exposures up to one hundred times greater than those now permitted by current regulations and practices . . . It is our best judgement that if the health and safety standards now in effect are rigorously enforced and followed, there is reason to believe that the Cluff Lake operation, from the standpoint of both accidental and potential radiation fatalities, will be, as we have already observed, as safe or safer than many other occupations now common in Saskatchewan.

In this and in other connections the Board defined acceptable as "combining experience, expertise, common sense, and the level of the public's tolerance particularly as it is expressed in common everyday activities."

On the subject of nuclear wastes, the report stated:

If proper abandonment and reclamation procedures are followed the long term effect upon the environment [of tailings piles] may be no greater than those from the ore body from which the material originated, but nevertheless surveillance should be planned on a regular long term basis. . . .

Although much research remains to be done, the problems involved in the safe long term storage of nuclear wastes do not appear to be insurmountable. We find that the problems associated with the long term waste management are not such as to justify a decision that Saskatchewan should not proceed with further uranium development.

A chapter on Proliferation and Terrorism filled a long-felt need by providing an impartial analysis of this important and emotive subject. The Board's findings included:

We are satisfied that a nation would not likely use its present domestic nuclear power reactors as its source of fissile materials for weapons. Besides the lower cost of small separate facilities. . . the nation could maintain greater secrecy and cause less disruption to her electrical supply by using small facilities intended for weapons production within her military establishment. . . .

In the final analysis, the controlling factor in determining whether a nation will acquire nuclear weapons is not the ready availability of nuclear materials but the political will of that nation. . . .

Terrorism involving nuclear materials will not be prevented by withholding from the world market the uranium which Saskatchewan has to offer. Nor will the incidence of such terrorism be reduced, even fractionally, by that withholding.

The report broke new ground by including a 24-page chapter on the Moral and Ethical Issues in the Development and Use of Nuclear Energy. In it, the Board re-examines the technical conclusions from previous chapters in the light of two explicit premises:

The development of natural resources as an instrumental good for enhancing the quality of human life is not only justified but laudable. . . .

In devising methods to use the resources of nature, care must be taken to ensure that the beneficial results outweigh the unintended and undesirable consequences.

In this chapter, the Board examined the arguments of advocates of "Soft Energy Paths", particularly Amory Lovins. It credited him with having "helped to force industry and government to examine their predictions of energy growth and estimates of renewable resources of energy", but concluded:

Lovins has made a moral judgement that nuclear energy is not only bad for society but is also unnecessary and, therefore, the motives and intentions of those who promote the use of nuclear power are also suspect. The standards which he uses are, in our view, too simple to answer the ethical questions of nuclear power in today's world.

The Board commented on those advocating a moratorium on uranium development thus:

Not one advocate of a moratorium addressed himself to any of these or like questions [12 questions listed] — some of which clearly have moral and ethical implications. . . .

The churches which advocated a moratorium did not deal with the moral and ethical side of a decision to impose a moratorium.

The Board's general conclusions respecting moral obligations were:

1. The monitoring of uranium mine/mill operations is a moral obligation upon the regulatory agencies;
2. the enforcement of agreements and regulations is a moral obligation upon governing agencies;

3. the adherence to specified regulations and agreements is a moral obligation upon the industry and its agents;
4. diligence in determining and setting safety standards for the nuclear industry is a moral obligation upon persons and bodies who have assumed or are charged with those responsibilities;
5. seeking solutions in their area of expertise to ameliorate the undesirable and unintended results from the harnessing of nuclear power is a moral obligation on the scientific and technological community;
6. those moral obligations are humanly possible to fulfill; and
7. failure to comply with such regulations or to carry out regulatory responsibilities is a breach of moral trust.

**7.9 Parliamentary Inquiry into Radioactive Waste, 1978
(Mr. F. Leblanc, M.P.)**

Parliament's Standing Committee on Natural Resources, under the chairmanship of Mr. F. Leblanc, initiated an inquiry into radioactive wastes in 1977. The inquiry was based on the "Hare Report", The Management of Canada's Nuclear Wastes (see Section 7.7). The Committee received nearly one hundred written briefs, and held 21 meetings, of which 18 were hearings. The Committee's term lapsed before the inquiry was completed, and only an Interim Report was ever published, in June of 1978. This recommended that:

The government, given the existence of radioactive waste materials in Canada, consider the advisability of having the appropriate governmental group or agency expedite a program of research and development in Nuclear Waste Management.

**7.10 Royal Commission on Electric Power Planning (RCEPP),
1978/80 (Dr. A. Porter)**

The Ontario government established a Royal Commission in mid-1975 to inquire into various aspects of Ontario Hydro's long-term planning. Nuclear energy was not specifically mentioned in the original terms of reference, but during the early stages of the Commission's activities it became apparent that this aspect would be highly controversial. Accordingly, much of the Commission's time was devoted to nuclear energy, and an Interim Report, devoted exclusively to nuclear energy, was published in 1978, in advance of the Final Report in 1980.

The Commission consisted of five individuals, chaired by Dr. Arthur Porter, Professor of Industrial Engineering at the University of Toronto. Preliminary meetings were held across Ontario in 1975 to determine the issues of greatest concern to the public. In 1976, public information hearings were held, again across the province but predominantly in Toronto, to establish the current status on the various issues. Following the publication of nine Issues Papers (one on nuclear energy), debate stage hearings were held in Toronto. During the nuclear hearings, 52 submissions occupied 63 days. The Commission also sponsored public symposia and seminars on topics raised in the Issues Papers.

Dr. Porter particularly sought public participation in the process, and stressed the importance of the Commission in educating the public on the issues raised. In the nuclear hearings, critics of nuclear energy were not only given every encouragement to state their objections, in several instances they were funded by the RCEPP to prepare and present their cases and to cross-examine those advocating the technology. In these objectives, however, the Commission was

largely unsuccessful: participation at the hearings was almost entirely confined to proponents and opponents, while media coverage was minimal.

The Interim Report considered the following factors:

Health, environmental and safety concerns; the economics of nuclear power; social impacts and the status of the nuclear industry; uranium resources; social, ethical and political issues; nuclear weapons proliferation and plant security; regulation of nuclear power; alternative supply technologies and the future of nuclear power in Ontario.

The weakness of the report lay in the fact that, to a large extent, it summarized the arguments on each side, and then gave the Commission's conclusions without explanation. Since the conclusions did not match all the claims, the reader is left in doubt as to which were endorsed or rejected. Thus each side can quote selectively from the report to support its position.

The report's conclusions predominantly endorsed the pro-nuclear position:

The absolute safety of any industrial process, or human activity, including the generation of electricity, cannot be guaranteed. In the case of the CANDU reactor we have concluded that, within reasonable limits, the reactor is safe. . . .

The radioactive releases during the normal operation of a CANDU power station should not give rise to concern. . . .

On economic grounds CANDU nuclear and coal generation are the major realistic options for new and large scale base load supply of electricity in Ontario in the late 1980s and 1990s. . . .

Ontario Hydro's security measures, including those currently being undertaken, are adequate. . . . These security measures are not likely to limit our civil liberties. . . .

Ontario Hydro's nuclear power programme does not contribute to nuclear weapons proliferation by non-nuclear-weapons owner countries. . . .

The economic benefits and the energy potential available to Canadians from our uranium base and from CANDU technology are significant.

However, the report included reservations that supported the anti-nuclear position. The one most often cited concerns the disposal of nuclear wastes. The Interim Report concluded:

An independent review committee should be established to report to the Atomic Energy Control Board (AECB) on progress on waste disposal research and demonstration. If the committee is not satisfied with progress by 1985, a moratorium on additional nuclear power stations would be justified.

The conclusion was repeated in slightly different words, but with the date changed from 1985 to 1990, in the Final Report. Opponents have interpreted this as calling for a moratorium unless an acceptable solution is agreed, while proponents claim that satisfactory progress on the research and demonstration has been achieved by the due date.

Other reservations in the Interim Report include:

Overdependence on nuclear energy would result in a system with inadequate resilience and too vulnerable to interruption.

The difficulties of obtaining sufficient capital for a major nuclear programme are serious enough that capital availability should be considered as an important constraint in assessing the proportion of nuclear power in the generation mix. . . .

The availability of indigenous uranium and associated production capacity presents serious potential constraints. . . .

We are not, however, prepared to endorse the inclusion of advanced fuel cycles [involving fuel reprocessing] in Ontario Hydro's system planning at this time. . . . Although we do not endorse this path [advanced fuel cycles], certainly not before the year 2000, we believe that the research should be continued. [In the Final Report, 2000 was changed to 1990.]

The Final Report, published in 1980, stated that "with few exceptions . . . the major findings of our earlier report . . . may be treated as final conclusions. "

7.11 Quebec Legislature Hearings into Les Politiques Energetiques du Quebec, 1978 (M. Patrie Laplante)

La Commission Permanente des Richesses Naturelles et des Terres et Forets of the Quebec Legislature held seven days of hearings into "Les Politiques Energetiques du Quebec" during February of 1977. As follow-up, the Government of Quebec, through the Minister responsible for energy, M. Guy Joron, issued a White Paper "Energy in Quebec — The Problems" in 1977 December, and a report "An Energy Policy for Quebec: Insurance for the Future" in 1978 June. The latter report is reviewed here.

The policy's goals are stated to be energy efficiency, self-sufficiency for Quebec, security of supply, employment in Quebec and a made-in-Quebec policy that would consider economic benefits, environmental effects and other factors. While energy conservation is accorded a high priority, it is expected only to slow the growth in demand, not to reverse the trend. Price rises, environmental awareness and technological advances can all be expected to moderate demand growth, but no sudden changes are foreseen:

Dramatic changes in individual lifestyle cannot be expected over the next two decades; what can be expected is a continuation of the trends which have recently become apparent. The tendency towards greater quality rather than quantity in lifestyle, better use of time and space, and more sensible choices with regard to goods and services all reflect a gradual change in the values of our society and should account for a more moderate increase in our energy needs.

Quebec has virtually no domestic supplies of oil, natural gas or coal. It estimates that alternative energy sources (i.e., solar, wind, wood, peat and domestic wastes) might contribute up to two per cent of the total supply by 1990; and the objective is five per cent by 2000.

Electricity is therefore the key to Quebec's energy policy. Quebec was already a world leader in hydroelectricity and long-distance transmission: among industrialized jurisdictions, it was second only to Norway in proportion of total energy demand met by hydroelectricity. Largely due to a desire to substitute electricity for other energy forms, the policy's objective is to increase electricity's share from 22 per cent in 1975 to 41 per cent in 1990, and 50 per cent in 2000. This implies an annual increase of 5.6 per cent, despite a vigorous program for improved efficiency and conservation.

Quebec, with much hydroelectric capacity still untapped, bases its energy policy on this technology, with resulting benefits in employment and self-sufficiency. With regards to nuclear energy, the report identifies the problems as public resistance, safety, and security against diversion to military purposes; it refers to the Quebec government's moratorium till 1980 on

committing any further nuclear generating stations beyond the Gentilly-2 station, then under construction.

However, a review of the negotiations with the federal government over conditions under which further stations would be committed shows that the resistance is concerned with reaching an agreement on a cost-sharing formula, and not any fundamental objection to nuclear energy. Indeed,

One of the government's objectives in this field [nuclear fission] is to ensure a transfer of technology to Quebec. . . . Although Quebec is in the enviable position of not having to commit itself to a nuclear energy program, there is no reason why it should deprive itself of a technology which Quebecers have helped to develop through their tax dollars.

It is apparent that the Quebec government wishes to retain the nuclear option against the time when all its economic hydroelectric potential is exploited. Furthermore, the continuing development of nuclear fusion is seen as a major component of Quebec's energy policy.

**7.12 Ontario Select Committee on Ontario Hydro Affairs, 1980
(Mr. D.C. McDonald, M.P.P.)**

At the end of 1977, the Ontario Legislature established a committee of fourteen members, (6 Progressive Conservative, 4 Liberal and 4 New Democratic Party (NDP)), with Mr. Donald C. Macdonald (NDP) as chairman. Its mandate was to examine several specific aspects of Ontario Hydro affairs: sixteen weeks of hearings, spread over about a year, were devoted to the safety of Ontario's nuclear reactors. Their design, licensing and operation were examined, as well as the utility's compliance with regulations. The Committee was assisted by Legislature staff.

The Committee had the daunting task of assessing a vast amount of evidence: presentations by 100 witnesses, 150 exhibits and 436 volumes of largely technical information, much of which had until then been unavailable to the public because it contained "commercially confidential" material.

The primary conclusion of the Committee was that Ontario's nuclear reactors were "acceptably safe." Three of the four NDP members recorded a dissenting opinion, to the effect that any judgement of what is acceptably safe must depend on the need for the product and on financial considerations.

The Committee concluded that the benefits of nuclear power (competitively priced, relatively non-polluting energy from Ontario sources) outweighed the risks, which were believed to be very small. It noted that the judgement of what is acceptably safe, considering the benefits, must be a political one made on behalf of society as a whole.

**7.13 Royal Commission of Inquiry into Health and Environmental Protection in Uranium Mining in British Columbia, 1980
(Dr. D.V. Bates)**

In 1979, the Government of British Columbia established the Royal Commission of Inquiry into Health and Environmental Protection in Uranium Mining in British Columbia, and appointed three Commissioners, of whom the Chairman was Dr. David Bates, Professor of Medicine and Physiology at the University of British Columbia. At that time, the prime purpose of the inquiry was to determine whether, and under what circumstances, uranium exploration should be allowed in British Columbia.

Initially, the Commission held a series of relatively informal community hearings and carried out on-site inspections of known uranium deposits. It subsequently planned a series of what were described as "technical hearings", but including ones on Social Impact, Ethical Questions, and Jurisdiction, Regulations and Enforcement. Before these were concluded, however, the British Columbia government announced a seven-year moratorium on uranium exploration in the province and terminated the Commission's mandate. The Commission subsequently obtained an extension to allow completion of its report, but not its hearings.

The Commission's Final Report, submitted in late 1980, recommends that the moratorium should be lifted, subject to certain provisions specified in the report, "in the belief that, with proper control, the possible risks attendant on this activity would be outweighed by the benefits of the knowledge gained." However, the British Columbia government immediately rejected this recommendation, stating that it "is of the opinion that the citizens of this province cannot, at this time, be convinced that any number of safeguards would be adequate."

The report does not recommend that uranium mining should proceed — that was not within the Commission's mandate — but rather it recommends the conditions under which exploration, mining and refining should be conducted should others decide to proceed with these activities.

The report is critical of past practices for uranium mining, in Canada and elsewhere, and of the Atomic Energy Control Board's record for national standard setting and enforcement in relation to uranium mining. However, the Commissioners included a unanimous statement resulting from their nearly two-year study of the subject:

We think it possible that in the future the requirements for energy may be so pressing that all the known uranium in the Western World has to be mobilized if our essential freedoms are to be protected. If this were the case now, with presently available technology, it would be possible to develop uranium mines but at the cost of some long term environmental degradation. A degree of protection could be provided for the work force superior to what has been customary in previous uranium mining.

We believe that the technology of tailings disposal is improving, and if adequate and generous research funding were provided, there are indications that in the next few years, uranium tailings, by extraction of radium-226 and thorium and by concentrating it, could be made environmentally as harmless as are any other mine tailings. Furthermore, at the present time, if the resolution to do so existed, the work force could be so well protected in our opinion, that the additional risks of uranium mining compared to other types of mining would be minimal. It is very possible, if enough attention is given to these matters, that at some time in the future when the demand for uranium from British Columbia is pressing, these two major problems of uranium mining will have been mitigated. The point has been made to us by representatives of industry, governments, unions and members of the academic community that research and development to improve the safety of all aspects of uranium mining is of relatively recent origin. We anticipate the likelihood of advances in the future.

The report constitutes a valuable compendium of information relating to uranium mining, organized in chapters entitled Radiation and Uranium Geochemistry, Worker and Public Health, Environment, Exploration, Mining, Milling and Chemical Extraction of Uranium Ores, Waste Management and Regulatory Process. The index of evidence identifies 63 items relevant to ethics, but more than half were submissions presented following the termination of the public hearings, and there is no chapter on ethics in the report. The Commissioners, however, conclude:

We do not take a position that there is any ethical or moral basis, regardless of improvements in these matters [referred to in the previous quotation] which may

well occur in the future, which would absolutely forbid the development of uranium mining. . . .

In the intervening period, provided that proper controls of such activity are structured and implemented, and provided that it is considered prudent to determine for the future what uranium resources may exist in the Province of British Columbia, we see no reason to prohibit uranium exploration from the point of view of environmental protection or protection of public health.

7.14 Nova Scotia Uranium Inquiry, 1985 (Mr. Justice McLeave)

The Nova Scotia Uranium Inquiry was established early in 1982, to study "all aspects of exploration, development, mining, processing, storage, waste management and transportation of uranium in any form." The main emphasis was to be on environmental protection for uranium exploration and mining. Mr. Justice Robert J. McLeave was appointed Commissioner.

The background to the Inquiry was an increasing amount of uranium exploration in Nova Scotia, discovery of significant occurrences, and expressions of public concern over the prospect of uranium mining. Trespassing and tree felling by some prospectors had caused considerable ill feeling. One week before the Inquiry was established, the Nova Scotia Minister of Mines and Energy halted uranium exploration while the Inquiry was in process.

The Inquiry started by inviting all those interested to help identify the relevant issues at 44 public meetings held throughout the province during 1982. A digest of the submissions at these meetings accompanies the report. About the time of the first meeting, Kidd Creek Mines Limited (the only major uranium mining company then still active in Nova Scotia) decided to cease mineral exploration in Canada and to withdraw from the Inquiry: a glut in the international uranium market had resulted in a collapse of the price in 1980. Its withdrawal would have had the effect that there would have been no institutional proponent for uranium mining in subsequent phases of the Inquiry. Under these changed circumstances, the Commissioner decided to redirect the Inquiry to:

- identify the issues accompanying uranium exploitation,
- recommend the process leading to such exploitation,
- recommend action on the existing ban on exploration, and
- recommend what should be done when uranium appears in the mining of other minerals.

The confrontational process to determine whether uranium should be explored for and mined would be deferred until there was a specific proposal.

The report is largely concerned with relevant legislation, specifically the division of powers between the federal and provincial governments. Topics identified for explicit review are trespass; prospecting and exploration; health and environment; mining, milling and jurisdiction; the ban on mineral exploration; chance discoveries of uranium; a visit to Bancroft (the site of a closed uranium mine in Ontario); tailings disposal; and markets for uranium.

The general conclusions of the report include the statements that "Methods exist by which uranium can be mined safely" and that the provincial government could exert a large measure of control over the exploitation. However, it warns that "The uranium market for Nova Scotia would be an uncertain one" and that proper precautions would have to be exercised to avoid harm to human health and to the environment.

The eleven recommendations are mainly concerned with provincial legislation and regulation related to uranium exploitation. One recommendation was that the provincial government should reconsider its ban on uranium exploration in 1990; another identified two factors that should be considered:

Mining should be done properly, by a company of impeccable and proven standing and financial resources.

The Inquiry's personal preference would be uranium mined in Nova Scotia for use in Nova Scotia.

The latter represents an implicit endorsement of the application of nuclear energy.

The digest of the meetings constitutes a valuable source of information on the public perception of nuclear energy in Nova Scotia. The overwhelming impression is that virtually all individuals who took the trouble to make submissions were against nuclear energy in general and uranium exploitation in particular. Implicit in most submissions is the unquestioned assumption that uranium mining would result in serious health harm and widespread pollution, damaging agriculture, fishing, forestry and tourism. A dairy farmer, Ms. Jane Robertson:

had no doubt that her Jerseys would become an endangered species if uranium exploration and mining were pursued.

Another assumption was that jobs would be the only benefits. One submission, by Ms. Anne Bishop, even suggested that the jobs would be unwelcome since:

it gets harder to get unemployment insurance and social assistance because on paper the employment statistics go up.

Very few submissions quantify the risks or benefits; or compare the risks with those from traditional Nova Scotian occupations or from other energy sources.

Much of the opposition focusses on nuclear weapons based, apparently, on the belief that Canadian uranium could be used in these. Participants apparently were unaware of, or did not believe, assurances to the contrary in a submission by the Canadian Nuclear Association:

Canadian government policy required that all uranium have a peaceful end use. . . . Canada's nuclear trading partners were committed to a total non-proliferation policy. Thus, Canada has developed the most stringent safeguards policy of any nuclear trading country in the world.

The report proper states:

The Inquiry considers that much public anxiety would be alleviated should peaceful purposes be found for Nova Scotia uranium,

as if this were not already required by law.

An index to the digest identifies 19 submissions as concerned with "Ethical Considerations." All are anti-nuclear. The compiler, apparently, did not regard as relevant to ethics questions raised in pro-nuclear submissions, such as what risk is acceptable, and how it should be determined; how much of its resources society should devote to avoiding a premature death; and, generally, the benefits of jobs and energy.

7.15 Interfaith Program for Public Awareness of Nuclear Issues (IPPANI), 1985 (Ms. C. Hosek, Mr. L. Henderson, Dr. H. Adelman)

In 1983, representatives of religious faiths in Toronto initiated IPPANI "to provide a forum for discussion of the moral and ethical implications of domestic and international nuclear policies as they affect Canada." Three sets of week-long hearings were held in 1984 and a report was issued

in 1985, sponsored by the Anglican, Roman Catholic and United Churches, and the Baha'i and Jewish Communities of Toronto.

IPPANI originated in a small group of church activists and members of the anti-nuclear organization "Energy Probe". When their demand for a government-funded inquiry was rejected as unnecessary duplication of previous inquiries, they initiated their own. Their original agenda was so blatantly biased that some cosmetic changes had to be made to gain church sponsorship. Each week's hearing was under the control of a panel selected from thirteen reasonably impartial "prominent Canadians". Each panel was responsible for its own section of the report. The stated purpose of IPPANI was to be an experiment in involving the public in the nuclear debate. In this it failed dismally.

In broad terms, the report can be seen as an endorsement to a large extent of current Canadian government policies on nuclear energy. However, nuclear proponents could take little comfort from this fact, because of errors in the report and a lack of proper substantiation for its conclusions. At one stage the Organizing Committee was proposing an educational program based on the panels' findings, but this idea was dropped after the report was issued.

The panel on domestic nuclear issues identified only two nuclear concerns — nuclear wastes and the health effects of radiation — and its only recommendations were for minor extensions to existing programs. Otherwise, it was preoccupied with the decision-making process without particular relevance to nuclear energy, but, incredibly, made no reference to the Federal Parliament or the Provincial Legislatures.

The text of the section on Canada's international nuclear trade contained many conclusions, mostly endorsing the positions of participants who had presented pronuclear briefs. However, the only overall conclusion was very weak, viz., "Attempts by some presenters to impose standards on foreign situations struck [the panel] as simplistic and sometimes arrogant." Presentations by church groups had not objected to nuclear exports as such, but had repeated their demand to ban all Canadian trade with countries of which they disapprove.

The panel on Canada's involvement in nuclear arms recommended "as a major emphasis" that Canada should employ diplomatic means to ensure that a new and strengthened nuclear Non-Proliferation Treaty is in place by 1995, when the current treaty ends. It omitted any mention that successive Canadian governments have made this treaty the keystone of their non-proliferation policy, and that preparations were already underway for its renewal.

7.16 Ontario Select Committee on Energy (Darlington). 1985 (Mr. P.W. Andrewes, M.P.P)

In the fall of 1985, the Ontario Legislature's Select Committee on Energy, consisting of eleven members chaired by Mr. P.W. Andrewes, decided to focus its activities on Ontario Hydro's Darlington Nuclear Generating Station, then under construction.

In its report, issued in December of that year, it concluded:

Load growth forecasts have changed so dramatically that all [four] units of Darlington are not likely to be needed to meet demand until the turn of the century.

Although the construction of Darlington would help Ontario Hydro meet acid gas emission standards, it is not needed for this purpose alone because viable alternatives exist.

[The primary justification for Darlington was therefore cost minimization.] The cost advantages of Darlington over coal-fired stations exist within a relatively wide range of financial and demand variables.

[Although there had been concern that Ontario Hydro's borrowing for Darlington would have a negative impact on the province's credit rating,] Ontario Hydro's financing needs do not represent such a threat.

Accordingly, the Committee recommended that Units 1 and 2, with 80% of their costs then committed, should be completed (the two NDP members dissented), but that "no further significant contracts for units 3 and 4 should be let for materials not needed for construction during the next 6 months while the committee studies demand and supply options."

The Committee resumed its activities the following year with twelve days of hearings on demand and supply options in April. In July it issued its final report "Toward a Balanced Electricity System." This strongly endorsed conservation, but warned:

At this time. . . . Too little is known about the cost and timing of conservation to risk thousands of jobs and several billion dollars of investment. And no other supply options can compete with the low incremental costs of the Darlington units. Therefore proceeding with Darlington is the lowest risk option for the province in the short term.

The report also included much on the need for future planning.

The Committee made three succinct recommendations on Darlington and nuclear energy:

Because of Darlington's low incremental cost and the uncertainties associated with other short-term options, all units of Darlington should proceed on schedule.

In view of the established potential of other supply options and the apparent potential for pursuing demand management initiatives, no further commitment should be made for additional nuclear power stations at this time.

The Minister of Energy should appoint an independent panel of internationally-recognized experts to review, on a priority basis, the safety of the design, operating procedures and emergency plans associated with Ontario Hydro's CANDU nuclear generating plants. The panel should prepare a report to the Minister which should also be made available to Members of the Legislature.

The third recommendation was responding to concerns over the safety of all nuclear reactors, resulting from the accident at Chernobyl in the U.S.S.R. that had occurred in April.

The two NDP members dissented from the first two recommendations, believing there to be an "enormous surplus of electricity" in Ontario, but supported the third.

7.17 Ontario Nuclear Safety Review, 1988 (Dr. F.K. Hare)

At the end of 1986, Ontario's Energy Minister Vincent Kerrio appointed Professor F. Kenneth Hare as Commissioner to review "the safety of the design, operating procedures and emergency plans associated with Ontario Hydro's nuclear generating plants." The government required a scientific and technical review, not a public inquiry. The Commissioner was assisted by an eight-person Advisory Panel, including a well-known critic of nuclear energy, nominated by the Royal Society of Canada.

The review was performed by engaging consultants, inviting submissions, making visits and conducting interviews. During the review, additional public participation was obtained through a three-day workshop, when more than 60 briefs were discussed. Before publication in 1988 March, the Commissioner's report was reviewed by a three-person international panel, appointed by the Royal Society of Canada, to ensure that the review had addressed its terms of reference, that scholarly methods had been employed in assessing the facts, and that the recommendations were sustained by the text.

In the report, the Commissioner set out five principles underlying the review:

1. There can never be absolute safety in reactor design and operation. . . .
2. Users of all such dangerous technologies must accept defence-in-depth as their guiding principle. . . .
3. The assurance of quality is absolutely cardinal to safety in nuclear technology, at all stages, and in all domains. . . .
4. There is some level of safety that the public finds acceptable. . . . [The] determination [of this] has to be political, not scientific. . . .
5. An alternative view is that there is a level of risk best called tolerable given the level of associated benefits. Whether or not this is perceived to be the case can be roughly measured scientifically, but decisions that a risk level is tolerable should only be made politically. . . .

The Commissioner proceeded to formulate 16 specific questions, which were addressed in subsequent sections of the report, and which formed the basis for the conclusions and recommendations.

The commission's "Major Conclusion" was stated clearly and succinctly:

The Ontario Hydro reactors are being operated safely and at high standards of technical performance. No significant adverse impact has been detected in either the work-force or the public. The risk of accidents serious enough to affect the public adversely can never be zero, but is very remote.

However, the Commissioner warned against complacency, stressing that "human performance of individuals and institutions is the key to future safety", and making specific recommendations to improve the safety culture within Ontario Hydro. The only other major recommendation was directed at improving the integrity of pressure tubes in the CANDU reactors. Other, detailed recommendations concerned the policies, organization and operation of Ontario Hydro, the Atomic Energy Control Board and Ontario's Nuclear Emergency Plan.

7.18 High-Level Radioactive Waste in Canada: The Eleventh Hour, 1988 (Mr. R. Brisco, M.P.)

During 1987, the House of Commons' Standing Committee on Environment and Forestry studied the storage and disposal of high-level radioactive waste in Canada. Supporting the thesis that nuclear energy is justified only if certain problems, including waste management, can be satisfactorily solved, the committee confined itself to this issue. It deliberately excluded consideration of the consequences of a moratorium on nuclear energy. Nevertheless, one of its recommendations, and probably the most frequently quoted one, is:

A moratorium on the construction of nuclear power plants in Canada should be imposed until the people of Canada have agreed on an acceptable solution for the disposal of high-level radioactive waste.

Another recommendation, however, endorsed AECL's nuclear waste management program to provide that solution. Others identified what would be required to establish that the proposed solution is acceptable. Some of these have since been satisfied by the federal government submitting AECL's concept for the disposal of nuclear fuel wastes to review by Environment Canada's Federal Environmental Assessment Review Process. One recommendation that has not been implemented was to make the AECB responsible to Environment Canada.

These points were made by the Government of Canada, through its Departments of Energy, Mines and Resources and of the Environment, in a response to each of the recommendations in the Committee's report. With specific reference to the question of a possible moratorium, the response stated:

The Government sees nuclear power as a useful part of Canada's energy mix and believes that this option should remain available for those provinces who make the decisions on sources of electricity generation. If nuclear power were not available, new capacity would have to be supplied by other sources that might be less attractive economically, environmentally, and in terms of the wastes they would produce.

**7.19 Nuclear Energy: Unmasking the Mystery, 1988
(Ms. B. Sparrow, M.P.)**

In 1987, the House of Commons' Standing Committee on Energy, Mines and Resources, concerned over the prospects of a declining supply of conventional light crude oil and of increasing environmental harm from the burning of fossil fuels, decided to investigate nuclear energy in Canada, for which there had been up to then "no comprehensive review by Parliament".

The Committee's primary conclusion was:

Maintaining the nuclear option is vital to Canada's interests, as it is vital to the interests of society in general. There is a compelling case to be made in support of continued nuclear development, a case based upon the future inadequacy of conventional petroleum resources and upon the environmental degradation arising from burning coal in progressively greater quantities for electricity generation.

Its support for nuclear energy, however, was not uncritical. Most important, it urged acceleration of the program for the disposal of high-level radioactive wastes, noting that "the technical problems of radioactive waste management are not insurmountable." It also recommended revision of the 1970 Nuclear Liability Act that determines insurance coverage for nuclear plants, and organizational changes in both the Atomic Energy Control Board and Atomic Energy of Canada Limited.

**7.20 Energy and Canadians into the 21st Century, 1988
(Mr. T.E. Kierans)**

The Energy Options Advisory Committee, established by Marcel Masse, Federal Minister of Energy Mines and Resources, went out of its way to obtain input from all sectors of Canadian society, representing a very broad range of views on energy policy for Canada. Its product was a recommendation for an energy policy framework based on seven principles related to: energy and development, energy security, energy and the environment, energy and markets, energy and the fiscal system, energy efficiency, and energy and technology.

In one section of the Committee's report, these principles were applied to the nuclear option. Its three major conclusions, with a summary of the reasons for them, were:

The nuclear option should be sustained as a component of Canada's energy mix. [The demands for energy in general, and electricity in particular, are likely to increase, and large generating stations will continue to be required.] Nuclear generation in Canada has been a reliable source of power at relatively predictable and stable costs [affording] a comparative economic advantage. . . . It presently has environmental advantages over coal [and] the possibility exists that global climatic change caused by the combustion of fossil fuels could reinforce the need for nuclear power. . . .

To clarify the issues and strengthen the public consensus, the federal government should seek independent advice on all aspects of the nuclear issue, from industrial policy issues to the safe disposal of wastes. . . . In the final analysis . . . the issues in the nuclear debate are institutional credibility and political leadership. A number of Canadians either are dubious about the claims and reassurances offered by supporters of the nuclear option or are waiting on governments to decide and enunciate firm policies for the future. . . . The nuclear debate . . . is not grounded in an authoritative, comprehensive and broadly accepted data base. [An independent review should be examined by Parliament, after which the government should implement the preferred option.]

[While] the process will be time-consuming . . . [the Committee] does not believe . . . that a federally imposed moratorium on the construction of additional reactors in Canada during this period is justified. [A moratorium would not significantly affect the waste-disposal problem and might unnecessarily prejudice the government's decision and prejudice options.]

7.21 Ontario Nuclear Cost Inquiry, 1989 (Mr. R.F. Brooks)

As part of the Ontario Government's review of Ontario Hydro's study of future demand/supply options for electricity in that province, it examined the utility's cost projections for nuclear electricity. Because these were remarkably low, Energy Minister Robert C. Wong established an independent panel to assess the validity of Ontario Hydro's methods and assumptions in estimating costs for electricity from nuclear energy and realistic alternatives. The panel was specifically directed to ensure inclusion of future costs for waste disposal and station decommissioning.

While the panel warned of the inevitable uncertainty of forecasts, and made some suggestions for improvements in the utility's presentation, its essential conclusion was:

The latest estimates by [Ontario] Hydro for its next nuclear station [are] methodologically sound, comprehensive and of high quality. These estimates, in our opinion, provide an appropriate basis for comparing options and preparing plans to meet Ontario's future electrical needs.

8. CONCLUSIONS

The first and most obvious conclusion from this review is that nationally and internationally there have been many—more than thirty—inquiries relevant to nuclear energy. The second is that, while some inquiries have been broad in scope and others have treated only a single topic, between them all conceivable topics have been covered. These include not only technical topics such as reactor safety, but also ethics.

Several of the resulting reports make recommendations to improve the current situation, often with regard to maintaining or improving the safety record; some conclude that nuclear energy is not yet needed in a national energy program; and one recommended a moratorium on new nuclear power plants in Canada pending agreement on waste disposal. However, the most striking observation is that none rejects nuclear energy, when needed and under stipulated conditions.

The inquiries reviewed cover a wide spectrum of styles, from parliamentary committees, through royal commissions and a self-appointed religious organization, to major international studies. A comparison produces some interesting conclusions, subject to the usual reservations regarding generalizations. An inquiry presided over by a jurist is judicial in style, with the jurist making a clear judgement of the issue based on the evidence presented. An inquiry composed largely of academics tends to be more "two-handed (on the one hand this, on the other hand that)", providing many statements to be quoted selectively by proponents and critics. The more individuals that are involved in the inquiry, the less clear-cut are the conclusions. An international inquiry, representing many diverse national policies, can only reach general conclusions to achieve political consensus. The most useful reports, and those of longest lasting value, are those that analyse the arguments, render judgements and provide reasons for the judgements.

The duration of the inquiries varied widely. Here the conclusion is simply that there is no free lunch. To do justice to these topics takes many months, up to a few years, even for the approval of a specific plant.

The review provides illustrations of some useful techniques for conducting an inquiry. Several inquiries have held preliminary, relatively informal, hearings to help them establish the scope of the review. Some have at the start translated their general terms of reference into precise questions that were later answered in the conclusions of the final report. Mr. Justice Parker (Windscale Inquiry, Section 2.2) required participants to conduct specific tests to resolve differences of fact that arose during the inquiry. The integrity of the Ontario Nuclear Safety Review (Section 7.17) was enhanced by two independent review panels, appointed by the Royal Society of Canada. Some of the international and U.S. inquiries with very large membership have used the technique of multiple scenarios to avoid the necessity of achieving consensus in predicting supply and demand, or in recommending politically divisive policies.

A final conclusion is that, contrary to critics' claims, nuclear energy in Canada has been subject to Parliamentary review from the start. It has received some criticism from time to time, but has benefitted from consistent government support for over four decades.

ACKNOWLEDGEMENTS

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