SCIENCE COUNCIL OF CANADA

The Proposal for an Intense Neutron Generator

Initial Assessment and Recommendations

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Report No. 2

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DECEMBER 1967

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The Right Honourable LESTER B. PEARSON, P.C., M.P.,
Prime Minister of Canada,
Parliament Buildings,
Ottawa, Canada.

Dear Sir,

In accordance with the provisions of sections eleven and thirteen of the Science Council of Canada Act, I submit herewith the views and recommendations of the Council with respect to the proposal for an intense neutron generator, in the form of a report under the title "The Proposal for an Intense Neutron Generator, Initial Assessment and Recommendations".

The proposal was made by Atomic Energy of Canada Limited and the Council's activities have been in response to a request for evaluation by the Minister of Energy, Mines and Resources. Background material to this report was prepared by a Committee of Council and is being published as Science Secretariat Special Study No. 4 under the title "The Proposal for an Intense Neutron Generator, Scientific and Economic Evaluation".

Yours very truly,

O. M. SOLANDT,
Chairman.

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PROCEDURE

The request from the Minister of Energy, Mines and Resources (Appendix I) was referred to the Council at its second meeting on October 4, 1966, whereupon an *ad hoc* committee was appointed and was asked to study the proposal in detail and report back in approximately six months. The membership of the committee was as follows:

*Mr. J. D. Houlding (Chairman)
President, RCA Victor Company Limited, Montreal

*Dr. O. M. Solandt (*ex officio*)
Chairman, Science Council of Canada

*Dr. W. M. Armstrong
Dean, Faculty of Applied Science, University of British Columbia

Mr. J. L. Couillard
Economic Council of Canada

*Dr. Leon Katz
Director, Accelerator Laboratory, University of Saskatchewan

*Dr. F. C. MacIntosh
Drake Professor of Physiology, McGill University

Dr. H. G. Thode
President, McMaster University

*Mr. D. Wermenlinger
Cartier, Coté, Piette, Boulva, Wermenlinger, et Associés, consulting engineers

Dr. R. W. Jackson and Dr. D. W. Henderson of the Science Secretariat staff participated fully in the work of the Committee.

The Committee held five meetings, including one at Chalk River with the staff of the Chalk River Nuclear Laboratories. The Committee was greatly assisted by thorough documentation prepared by the staff of AECL and by replies from AECL in response to specific questions. An independent assessment of the technical feasibility and the cost estimates for the Intense Neutron Generator was prepared by two consultants engaged by the Committee—Dr. R. E. Taylor of the Stanford Linear Accelerator Center, Stanford, California, and Dr. J. P. Blewett, of the Brookhaven National Laboratory, Upton, New York. An assessment of the immediate and long-term impact of the project

* Members of the Science Council.

upon Canadian industry was provided by officers of the Department of Industry. In addition, the Science Secretariat was able to prepare a forecast of possible trends in the future funding of research by the Federal Government. All of the above information was vital to the work of the Committee.

The Committee presented its findings to the Science Council at the meeting held on March 17, 1967. After full discussion, the Council approved without dissent the following statement of Observations and Recommendations, noting that supporting documents would be assembled in the form of an Appendix to this report as expeditiously as possible.

OBSERVATIONS

For a country of Canada's size, it becomes essential that there be a degree of specialization in scientific research and industrial technology if Canadian efforts are to achieve internationally significant and competitive levels. Specialization in areas of basic national need or significance, with dedication to a standard of excellence in the chosen areas, is not only the best way to challenge our scientists and engineers, and keep them in Canada, but is also the way to ensure the greatest long-term returns to the economy.

The ING project meets those criteria. It is a project of national and international significance, it is related to an area in which Canada already has an important investment, and is one of the few areas in which Canada has already an international stature—in both basic science and technology. It is one of the very few projects that have been presented in this advanced form. Moreover it possesses features that are vital to the success of any research project and that are not easy to call up at will: an original, well-conceived idea, which dares to push to the frontiers of technology; and the backing of an enthusiastic group of people of proven competence and reputation to carry it through.

The longer term industrial and economic significance of ING relates to the provision of low-cost electric power. The generation of electric power by atomic energy is in a phase of rapid expansion, having passed the point of competing economically with fossil fuels and with hydro in many circumstances. Canada is fortunate in having acquired a strong position in the development of nuclear power reactors of the heavy-water moderated type. This type is one of the strongest contenders to continue in world-wide use as complementary to "breeder" reactors, even should breeders become economically competitive as a result of the intensive research in the U.S., France, and U.K. Also it is the logical choice for Canada's own needs for many decades to come because of our rich resources of natural uranium.

Canada's present position has come about because Atomic Energy of Canada Limited has used sound engineering judgment to exploit an early start in the field and a strong basic research program into the achievement of practical results. It is important that this overall effort be continued and that Canada maintain its competitive position in reactor design.

In addition to the atomic power program itself, there have been other useful benefits to industrial capability and secondary manufacturing. In the latter category is the successful and rapidly expanding isotopes sales and applications business, set up by AECL under their Commercial Products Division.

However, as the large markets for nuclear power reactors and components, and for radioisotopes, open up, the competition from other countries

of the world is stiffening. Furthermore, the development of still more efficient nuclear reactors is continuing, and will continue into the foreseeable future. Under these circumstances it is particularly important that AECL make every effort to maintain and exploit their present advantages, and gird themselves to keep in the forefront of new developments over the long term. A continued strong and appropriately balanced research program is essential for this endeavor.

The Science Council has studied the AECL proposal for an Intense Neutron Generator as a major facility for basic research related to the AECL program in the decade beginning about 1974 or 1975. The Council concludes that the essential idea of generating neutrons by spallation is well-conceived, and the unique prototype design around a proton linear accelerator appears feasible, although further exploratory development is needed before the choice of design is final, and before the costs of overcoming the problems can be estimated firmly enough to commit full funding to construction.

If the only purpose of the project were for basic physics research within AECL, the cost might not be justified. However, the project has also potentially important technological and commercial implications. (An approximate breakdown of the various uses and purposes of the facility puts about 60 per cent of the value to basic research, and 40 per cent to applied reactor research, materials testing, electromagnetics technology, and isotope production.) In addition it is proposed to operate the project as a national facility with strong university participation. Thus, to arrive at a fair evaluation of the total benefits to the Canadian economy, the Council has had to analyze the scientific and technological significance under several headings (a) to AECL, (b) to the scientific community, (c) to the universities, (d) to industry, and (e) to the nation and the public.

Summarized from those headings, some of the desirable features of the proposed facility are:

(1) It will exploit and build upon the research experience and reputation of the Chalk River Nuclear Laboratories in neutron physics.

(2) It will maintain Canadian science and technology in an advantageous position for the exchange of advanced information on new scientific and technological developments as they appear anywhere in the world.

(3) It will build a strong interrelationship with the universities in basic and applied research, improving the transfer of ideas and motivations between research in the universities and the engineering objectives of the project.

(4) It will broaden the Canadian technological base into advanced electromagnetics. The physics research and electrical engineering in this area could bear a productive relationship to the more directly applied research on electrical power generation, transmission, and distribution now being initiated, e.g. by Hydro-Quebec. Potentially, it could provide substantial stimulation of new technology and new products in Canadian industry. An analysis prepared by the Department of Industry indicates that during the construction phase up

to 85 per cent of the labor and components included in the design, engineering, equipment fabrication, and site development would be provided by Canadian companies.

(5) It will provide for research on problems closely related to the next generation of reactors, including breeder reactors, as, for example, liquid-metal cooling, and development of materials for intense radiation fluxes.

(6) It will produce commercially valuable radioisotopes, providing a basis for substantially expanding sales of the Commercial Products Division. (Attempts to predict Canada's share of the world isotopes market in 1980 show wide variance, but the intense neutron flux would mean the capability to produce isotopes of high specific activity, and isotopes of certain elements, with much greater efficiency than they could be produced in reactors. AECL has estimated the direct annual revenue to the facility from isotope production by 1980 as between $5 million and $15 million, 1966 dollars, implying gross sales between $20 million and $75 million.)

(7) For the Canadian university and scientific community generally, the ING would provide an unparalleled facility for basic research with intense fluxes of neutrons, protons, and mesons. The facility would be unique enough, and scientifically important enough, to have significant status in the international community and thus to keep open for Canadian scientists the important reciprocal relationships for information flow and the use of major facilities in other countries. The Council endorses this approach as preferable to attempting to compete directly by building major equipments similar to those being built abroad.

Provided that access is sufficiently convenient and that the university scientists have had a sufficient role in the planning of the facility, the university community would likely make substantial use of the facility. By 1980, the number of university scientists using ING is estimated to be about 50, with perhaps twice that number of graduate students involved. Additional numbers from applied science and engineering faculties will be involved in studies related to the engineering problems of improving and exploiting the machine. Nevertheless, analysis shows that the participation of the universities would not be out of scale with the much larger total of research activities in the universities themselves at that time (perhaps 1 per cent to 2 per cent by 1975; more specifically, projections for the field of nuclear physics show probably not more than 10 per cent of total university nuclear physics, on a basis of expenditures).

The Council has examined the manpower needs of the project and finds the demands modest in comparison with the expected supply. (In 1974, 3 per cent of the Ph.D. physicists would be involved with research on ING.) There may be a shortage within Canada of certain needed specialists, and scientists of exceptional quality, but in this respect the project would more than likely have a beneficial effect, in that it would provide sufficient excitement and challenge to draw top-quality scientists and engineers from abroad. The project would serve a useful function as a training ground within

Canada for scientists, engineers, and technologists to meet the technological challenge of the future.

The Council, with the help of independent consultants, has examined the cost estimates for the project, and finds them reasonably accurate and inclusive, considering that further design studies are yet to be done before detailed engineering and firm costing will be possible. The present estimates call for a total of 155 million 1966 dollars by the end of fiscal 1973.

The Council has considered carefully the magnitude of the expenditures proposed, in relation to expected national expenditures on research and development over the next 10 or 15 years, and in relation to the demands for funds that can be envisaged for other scientific and engineering projects. The proposed expenditures for the ING project appear reasonably within the means of the national budget, along with several major national programs, provided only that the total national expenditure on R & D is allowed to rise to a level about 2 per cent of the Gross National Product by 1975. (Canada spent an amount on R & D equivalent to about 1 per cent of GNP in 1965, compared with about 3 per cent in the U.S. and 2.3 per cent in the U.K.) The ING project would appear to introduce no serious interference with the demands of other programs, partly because it is one of a very few worthwhile large-scale projects that exist now in proposal form with a nucleus of staff and ideas around which rapid growth could take place almost immediately.

The Council has considered questions of the organization of the project and its location, so as to optimize the benefits of the project to AECL, the universities, and industry, and has incorporated its conclusions in the recommendations.

In addition to the very long range and broad benefits to the economy that are to be expected from basic scientific research, the Council has given considerable weight to the potential medium-range industrial and commercial outputs of the proposed project. However, those outputs will not necessarily come into commercial exploitation automatically. It is becoming widely recognized in most countries, by councils concerned with science policy, that the weak point in realizing the economic benefits from research and development performed in government or academic laboratories tends to be the entrepreneurial link. The Council is of the opinion that this would be best not left to chance, and suggests the provision in the organization of a mechanism for active promotion and exploitation of results from the project research and development, to the best interests of the economy.

Alternative projects or missions were considered briefly, including those earlier considered by AECL and from which ING was selected. The Council is prepared to support the judgment of AECL in selecting ING. Most other proposals were thought to be narrow in technological challenge. Some would have brought AECL into direct competition with, or duplication of, research established in other countries or in industry. Some would have implied the surrender of Canada's advantageous role in the international community of nuclear research and development. In short, the Council found none more suited than ING to the present circumstances.

RECOMMENDATIONS

1. Commendation

The Science Council recommends that AECL be commended for their foresight, imagination, and diligence in preparing a thoroughly documented proposal of broad scope, with high potential value to the long-range AECL program, to basic and applied research in the universities, and ultimately to the Canadian economy.

2. General Approval in Principle

The Council recommends that AECL be encouraged to proceed toward the objectives of the proposed project, subject to certain cautionary safeguards enumerated hereinafter.

3. Continuation of Design Studies

AECL should be funded to a total of about $7.5 million until March 1969 to pursue design studies, feasibility experiments, and studies on alternative systems to the point of developing a demonstrably feasible design with firm cost estimates.

4. Review before Commitment

Before commitment of funding to construction, the program should be subjected to careful review by the Science Council. Provided that the total costs still appeared within reasonable limits, it is recommended that approval should then be given to proceed with design and construction. If, on the other hand, the costs appeared excessive at that time, e.g. due to design or other changes not related to inflation, a decision would be taken as to whether to proceed with a modified program or to continue the study of alternative approaches. It is assumed that the essential objective of achieving intense neutron fluxes by spallation would remain.

5. Periodic Review

The Council recommends that the long-range program and budgetary forecast of the project should be subject to annual review of progress and expenditure, with re-definition of objectives and modifications to budgets introduced as necessary. The Council does not attempt to recommend priorities on the various functions the machine may perform, but advises that the planning of the program should be kept as flexible as possible, so that alternatives are kept open, and so that marginally useful functions can be dropped if necessary to keep the project within a prescribed budget.

6. Location

The Science Council is convinced that the effectiveness of university participation, interaction with industry, and total benefit to the economy will be enhanced by placing the facility at a location convenient to a major airport, and within commuting distance of one or more universities, industrial areas, and bi-cultural amenities. The Science Council Committee was not convinced that the Chalk River location would best meet those criteria. The Council recommends that detailed studies begin immediately to select a specific suitable site before the commitment of major construction.

7. Organization

The Council considers that the long-range organizational objective would be the establishment of a national institute for nuclear science. In the interim, however, the objectives of the project could best be met by immediately placing the project under a Board, chaired by the managing director of the project, and responsible to the Board of AECL through the President.

Appointments to the Board would be made on the recommendation of an impartial body that, working in consultation with AECL, would make its selection from persons nominated by the universities, industries, and the government. It is suggested that the impartial body be the Operating Committee of the Science Council, which is headed by the Chairman of the Council.

The type of organization recommended would ensure the fullest degree of co-operation with the AECL organization, which has initiated the proposal, and which will have an important and continuing responsibility for its development. The organization would also meet a requirement that the Council considers of fundamental importance, namely the active participation of the universities and industry in all major questions relating to the design, development, and operation of the facility.

The Council wishes to stress the importance that it attaches to the broadest dissemination and exploitation of the results of the research and development work done by the project (and later institute), and to their energetic development into industrial and commercial innovations. In this connection, additional funding may have to be allowed for within the project budget, or in budgets of other agencies, to help the organization meet this important objective.

APPENDIX I

Letter from Minister of Mines and Technical Surveys

22 September, 1966

Dr. O. M. Solandt,
Chairman, Science Council,
Privy Council Office,
East Block,
Ottawa, Ontario.

Dear Dr. Solandt:

Intense Neutron Generator

You are no doubt aware that AECL has been studying a long-term development in their programme that involves a new means of producing neutrons at very high intensities. The study has shown promise for a facility employing a powerful beam of high energy ions to produce neutrons in a liquid heavy metal target. AECL has now formulated a provisional proposal for such an Intense Neutron Generator (ING).

Early in the study a copy of a preliminary outline was sent to Dr. Forward on 5 March, 1965 in order to keep the Science Secretariat informed and subsequently meetings of AECL's ING Study Advisory Committee have been attended by a representative of the Secretariat. Last month a presentation was made by Dr. W. B. Lewis and other senior staff of AECL at Chalk River to members of the Advisory Panel on Scientific Policy, and to other senior officials in Ottawa, in order to explain the proposed facility and the justification of its development.

You will recognize that the proposal involves a facility of sufficiently large magnitude that the decision to proceed with construction will have to be made by the federal cabinet. Moreover, the timing affects the submission of Estimates for 1967-68 and subsequent years that are of particular interest to the Treasury Board.

The Intense Neutron Generator would provide extensive research facilities based not only on the neutrons but also on the mesons expected to be produced. There would also be a significant production of radioisotopes. The development of the facility calls for highly advanced engineering. Because of these features it may be desirable to establish a special organization in which universities are fully represented. In line with developments in other advanced countries the Intense Neutron Laboratory might be the first of a number of

similar institutes across the country. Special considerations will determine the location of ING and those already recognized are presented in the reports of the study now available.

In view of these wider interests and the magnitude of the project, the Executive Committee of the AECL Board of Directors has recommended that the advice of the Science Council should be sought. I understand that the request at this time for the Science Council to make a review was influenced by the indication that the Science Council could come up with a recommendation in about six months' time.

I support the AECL recommendation and am writing to ask the Science Council to give early consideration to the ING proposal and to make early recommendations. AECL will, of course, supply the Science Secretariat with all relevant information and would be ready to appear before any committee of the Science Council that considers the project.

Yours sincerely,

JEAN-LUC PEPIN,
Minister of Mines and Technical Surveys.

cc: Mr. R. G. Robertson
Dr. F. A. Forward

APPENDIX II

Reply to letter from Minister of Energy, Mines and Resources

Ottawa, March 31, 1967.

The Honourable Jean-Luc Pépin, P.C., M.P.,
Minister of Energy, Mines and Resources,
Ottawa, Ontario.

Dear, Mr. Pépin:

Intense Neutron Generator

In response to your request the Science Council has reviewed the proposal by Atomic Energy of Canada Limited to construct an Intense Neutron Generator Facility for long-range research related to the atomic energy program.

On behalf of the Council I am pleased to submit herewith "Report on the AECL Proposal for an Intense Neutron Generator". This report based on the results of a comprehensive study by a committee of the Council under the chairmanship of Mr. J. D. Houlding, carries the recommendations of the Council in respect of the proposal.

Briefly, the Council finds that the project is sound and imaginative; and that it is within the resources of funds and manpower than can be made available in Canada in the next eight years, taking into consideration the needs for expansion in all other areas of research, scientific activity and technological development requiring federal government support that can be envisaged in that time. It appears that as much as eighty-five per cent of the funds required for the design, equipment and construction of the facility would be spent in Canada and that, potentially, the stimulation of new technology and new products in Canadian industry would be substantial.

The Council recommends that the project be approved in principle and that up to $7,500,000 be expended over a two-year period for more advanced design and engineering studies with a further critical review by the Council at the end of that time and before commitment of funds for construction. Also recommended is that immediate steps be undertaken to determine a site (probably other than Chalk River) and to develop an administrative organization looking toward the formation of a National Institute in which the universities, industries and the government would participate jointly.

The numerous supporting documents constituting an Appendix to this Report are being assembled in suitable format and will be available in about

one month's time. Publication of any of the information in the Report or the Appendix is of course subject to your discretion and approval.

On behalf of the Council may I thank you, Sir, for offering to us this opportunity to participate in the examination of this interesting project. I hope that the views expressed in the Report will be helpful to you.

Yours very truly,

O. M. SOLANDT.

cc: The Right Hon. L. B. Pearson, P.C., M.P.,
Prime Minister of Canada,
Ottawa, Ontario.

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