WHAT'S AHEAD IN CANADA'S NUCLEAR FUTURE

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I am honoured to have this opportunity to address your luncheon today. My topic is Nuclear Power - a subject that occupies much of my day-to-day activities. However, it is not mere familiarity that prompts me to discuss this subject, but rather my very strong feelings about the benefits that nuclear power can give to the world, and especially to Canada. All Canadians should be aware of its potential. I will approach my subject from the viewpoint of an engineer but not inundate you with technical facts and figures. Instead, they will be the submerged base from which to outline the opportunities and challenges the remainder of this century has placed before us.

Civilization has learned in the past few decades what immense benefits it can reap through the widespread use of cheap power. Much of Canada's industry and the soundness of our economy is founded on cheap electricity generated from hydro resources. By the year 2000, providing there is no global war or widespread civil insurrection, the world will be consuming at least six times the electricity that we consume today, and probably much more - possibly more than ten times today's consumption.

In these days of rapid technological progress, it is difficult to quantitatively forecast ahead thirty years. But it is not rash to predict that most of this added electrical capacity will be provided by nuclear stations. On top of this, nuclear power will also be put to other uses such as in mammoth desalination plants and huge agri-cultural-industrial complexes.

The nuclear industry will double in size every five years.

At these rates of utilization, there is no other energy source known, either singly or in combination, that would not be strained and depleted so severely as to be uneconomic. Before the end of this century, new uranium ore discoveries and mine development will be hard pressed to keep ahead of demand. It may be necessary to tap the immense, but less economic, uranium deposits recoverable from the oceans. But the nuclear concept will not falter in meeting its challenge to provide safe economical power. Technological developments are now on the threshold of converting the world's thorium reserves into a usable fuel, and are about to extend the usefulness of the uranium reserves by breeding a more potent fissile material in the reactors.

To repeat, the need for electricity will increase tremendously over the next 30 years. Nuclear reactors provide a sure way of meeting this need.

The assertion "a sure way" perhaps deserves some justification. Today, and rightly so, we hear much about pollution of our environment. We are currently hearing much about air pollution from electrical generating stations. One would be rash indeed, in the light of present technical knowledge and public concern, to consider thermal power stations burning fossil fuels as a sure way of meeting tomorrow's energy needs. Consequently, we are very fortunate that the nuclear alternative not only presents an abundant energy source, but also one which we can apply economically and without contamination of our environment.

Pollution is becoming, and rightly so, such an influence in the decisions we reach that the relationship of nuclear power to pollution should be clearly understood, and by as many people as possible. Because the facts are that nuclear power is a positive force in our fight against contamination of our environment, not an offender. The nuclear process discharges neither waste chemical products nor radiation; instead, it keeps them sealed within the reactor vessel and the fuel elements. This is not the case with other thermal energy cycles. Fossil-fired plants, whether they be coal, oil or gas, rely on oxidizing combustion to release its chemical energy into heat. This brings our air directly into the process and imposes a need to clean the soot and poisonous gases from it before it is released from the station. The compromise between a marginal health criterion and the economic penalties of achieving a clean discharge is at long last swinging in favour of preserving our environment. With each such advance, nuclear power becomes that much more attractive. Such a move is already discernible in sourthern California where air pollution is of such concern that future power stations, other than nuclear, are likely to be prohibited. Sooner or later everyone will be faced with severe curtailment of many of our combustion processes because of the copious by-product gases produced. Coal-fired plants generating electricity will be one of the first to go. The ecological behavior of our whole planet is on the verge of significant change because of the steady increase in the proportion of carbon dioxide in our atmosphere. Nuclear power and hydro power will be the only respectable processes left that we can rely upon for our continuing electrical needs.

Before leaving the subject, something should be said about what is often called thermal pollution. This concerns the discharge of clean but warm water from power stations whether they be nuclear or fired with coal, oil, or gas, and it is now being attacked by some naturalists. When power stations are located on a relatively small and overloaded river -- and this is already the case in some parts of Europe and the United States -- significant ecological changes can be induced by the warm water discharged. However, nuclear plants can be sited, with perhaps some inconvenience but without significant economic penalty, on the oceans and on adequately-sized rivers and lakes so that the warmth added can be dissipated without changing the life patterns of the surrounding area. Furthermore, and particularly in northern climates such as ours, waste heat from nuclear power stations can be put to use to provide a useful secondary effect if we wish.

Nuclear power has an immediate competitor in coal-fired plants, but for two rather spurious reasons. The first is a hesitancy of some utilities to rely on nuclear power to meet their future needs because it is a fledgling industry, experiencing delays and start-up problems. However, if we wish to prevent coal-fired plants from continuing to pollute us they require costly new equipment that is as prone to development problems and delays as are the nuclear plants. The utilities admittedly have a difficult decision to make for their next generation of power stations. The analogy of how swiftly the airlines finally reacted to the displacement of the reciprocating engine with jets is a good preview of what to expect. The other argument against nuclear stations is that fossil-fired plants are cheaper to build.

However, nuclear stations cost less to operate and maintain and are less costly in the long run. If utilities have more difficulty raising capital now than covering operating costs by raising rates later, coal-fired stations offer some immediate financial relief. Undoubtedly, some will be built and we shall suffer further pollution - pollution that was not necessary simply because we didn't provide the capability to finance the better approach. On a completely broad-brush basis, the quickening pace of technology is providing mankind with an ever-expanding array of benefits, and most of them require a still greater expansion of capital investment. A way will have to be found financially to permit man to build what is feasible from his store of knowledge and possible from his productive capacity. As an engineer, I pass this challenge to those of you who reside in the financial community.

So much for the world situation; now what about Canada. With such a growth in nuclear reactors, there is going to be a healthy market in fuelling these reactors. Canada, and Ontario in particular, is one of the world's major uranium sources. Uranium is certainly a very attractive investment opportunity for Canadians in the long haul.

In talking about the fuel demands of electric power stations, we tend to think of the coal, oil or gas consumption per week, as demanded by the level of power produced. Except where coal has to be stockpiled over the navigational freeze-up, fuel supply is very much a low inventory proposition. Such a concept is not appropriate to nuclear power. Most reactor stations to be built in the next twenty years will have an initial fuel load sufficient for approximately four years of power production.

With installed nuclear capacity throughout the world doubling every four to five years, the major demand for uranium initially is just filling up the new reactors with sufficient fuel. In the next 15 years, only half of the fuel delivered to the reactors will be consumed to produce power, the other half will remain as core inventory for future utilization. Before 1980 the demand for uranium fuel will exceed present production capabilities to mine and process the ore. Since it takes several years to bring a mine into production, the pinch of uranium shortages will be apparent in a few more years despite the considerable over-capacity that the world-wide industry now faces. At present, U.S. production capacity and output is roughly three times that of Canada, but the Americans cannot hope to meet their domestic demand after 1975. However, until the U.S. market is open to Canadian producers or until other export demands from Europe and Asia rise near the end of the decade, Canada will have an over-capacity. Our proven reserves and our idle production capacity will, however, be most assuredly utilized in the years ahead. And it won't stop there. At the rate at which nuclear capacity will be increasing in the next decade and beyond, new mines must be discovered and milling facilities constructed. A quarter of a century ago we Canadians proved that we have geological formations throughout our country containing rich ore bodies and the ability to make these into efficient mining operations once the economic incentive is present. This incentive will return in a few years when the foreign utilities realize they can no longer risk putting off the day of making forward commitments at prices that will carry the cost of exploration and mine-mill construction.

We, in Canada, have been stressing that it is more prudent if the forward market is firmed up sooner rather than later. But whether the expansion is orderly or hectic, there is no alternative to Canada becoming a major uranium supplier to the world before the turn of the century.

While there are some uncertainties as to just when Canadian uranium production will zoom ahead, there are real uncertainties concerning its conversion to reactor fuel. Many reactors require that the active isotope of uranium be more concentrated than in the proportions found in nature. This is achieved only with much difficulty and great cost and the technical subtleties are kept secret. The world fuel demand to 1980 will be dominated by reactors requiring such enriched fuel. Its higher potency permits a chain reaction to be maintained when inexpensive neutron absorbing materials such as ordinary water and stainless steel are used in the reactor. The offsetting penalty is the high cost of enriching the fuel. If the active isotope, U-235, is used in its naturally occurring concentration, expensive neutron efficient materials such as zirconium and deuterium oxide must be used to maintain a chain reaction.

The United States erected huge diffusion enrichment plants in the forties for the weapons program. When demand slackened off, the surplus capacity was utilized to enrich fuel for electric power generation. Thus, the American reactors are quite different from the reactors in Canada. We have avoided the use of enriched fuel by opting to use deuterium oxide - commonly called heavy water. It is expensive since it, too, involved the concentration of two chemically similar isotopes.

Its procurement is not without its headaches - the failure of the Glace Bay plant to produce on schedule is a real disappointment and has placed heavy water in very short supply at this time. The basic heavy water process, however, is a proven one and its technology is available to us. Supply will satisfy the backlog once the two additional plants already under construction, at Port Hawkesbury and at Douglas Point, are in operation.

The dilemma shortly facing electrical utilities using or building reactors requiring enriched fuel is where to get additional fuel once the capacity of the present diffusion plants is fully utilized in about five years. Several European countries are pooling their resources to develop the centrifuge process, and Japan is also looking at it. It has the promise of more economical operation in smaller-sized plants than the existing diffusion process. Its development may not be completed in time to meet the shortage. Whether centrifuge or diffusion, the financial commitment is large. And the cost of the product from new facilities will be higher than the price at which the United States has provided enrichment in the past.

The Canadian Nuclear Association has studied the proposition of building an enrichment facility in Canada so that we could upgrade the product we export. Since it requires energy in large blocks, it does provide a method of utilizing and exporting the hydro potential of power sites in the far north which otherwise may be undeveloped for many, many years. But to do so we would have to import massive amounts of foreign capital -- and just to have an export product with about 10% added Canadian value. We should set our target higher, in terms of benefit to Canadians, for the foreign capital we import. Discussion on this subject is pertinent in the context of a comprehensive continental energy policy, but certainly secondary to

the immediate utilization of our uranium capacity. If we have oil, gas and water surplus to Canada's longer-term needs, then we certainly have a huge surplus of uranium. Our producers have been urging for a long time now that we obtain access to the U.S. market -- and advancement of the 1973 date for lifting the embargo is our objective.

Moving from the natural resource sector, what about the Canadian industrial sector? The future here is more than attractive -- in fact the potential is mind-boggling. To the year 2000, our share of the reactor market could by fifty billion dollars, which would certainly make the Canadian nuclear industry one of the more dominant factors in our economy. The potential is there because we have a good nuclear process, one that is different from our major competitor, and one for which a world-wide market is developing. It is insensitive to inflation, once built, because it is cheap to operate.

Why do we have a different process in Canada to that adopted south of the border? History played a part in our solution to the nuclear power equation. Canada became the custodian of nuclear research using heavy water during the war as Europe was too close to the hostilities. The scientific knowledge incubated here continued to flourish after the war and maintain our leadership. When electrical power via the nuclear process was considered feasible and desirable, we naturally explored the process we knew best. And it was not found lacking - to the contrary, it had the capability of meeting the stiff rate structure Canadian utilities had developed from hydro generated power. As a result, we have concentrated on what is now called the CANDU process.

Since starting our power program in 1954, we have scientifically confirmed its complete feasibility and attractiveness. Our pioneers at Chalk River and Rolphton should be given the accolades due them for they have done their job well. We have engineered, designed and developed prototype stations that have demonstrated the dependability, availability and economic performance of the CANDU system. Granted we have had our development troubles, and still more will likely be encountered. Such is the nature of a new technology. But our problems are no more numerous nor severe than those encountered in the American reactor program. We have only to diligently apply ourselves to their solution in like manner to the Americans to realize an equally successful outcome. Our nuclear program has been Canada's most extensive scientific venture and we have proved it to be a winning concept. To harvest what is now at hand we need to field an equally determined and effective marketing approach.

At present, our critics discount us as a major contender for world markets and there is nothing better than to heed honest criticism. So let us dissect this criticism, which perhaps is best condensed by American energy consultant Philip Sporn in the Columbia Journal of World Business. His first point of attack is that the Canadian-sponsored process will not match the cost of producing power by the U.S. processes. We want the huge U.S. market for reactors to be available to us, so their ground rules for evaluation have to be applied. And as long as light water reactors can obtain bargain priced enriched fuel from surplus government plants, the going for us will be rough.

But their enrichment facilities will shortly be inadequate. New facilities will have to be built. Within a few years, enriched fuel will have to carry the fixed capital charges on new diffusion or centrifuge facilities. If the Americans think that our reactor process is economically inferior to theirs because of the high capital charges at the rates they must pay to finance expansion, they should reflect on their total process. For it is a fact that the capital cost of the heavy water reactor stations plus the capital cost of the heavy water plants to fill these reactors with moderator is less than the capital cost of the light water reactors plus the capital cost of enrichment facilities to fill these reactors with fuel. Our complete process is less capital intensive and much less costly to operate. Furthermore, the capital cost of American reactors is moving closer to those of Canadian reactors. We should be mindful of what our critics have to say, but let us not be cajoled away from a sound avenue of concentrated effort by shallow arguments.

The second point our American critics make is that we are chauvinistic, we ignore the enzyme effect in industry, and we bar the door to private enterprise. We can only partially claim that these items of criticism are invalid. But let us explore one of them a little further - that of barring the door to private enterprise. In Canada the door has not been barred, although it has not been open as wide as in the United States. Canadian industry has had a large piece of the nuclear action as witnessed by the 900 firms that are suppliers to the Pickering Generating Station and which collectively account for 80% of the total effort.

We have a substantial industrial base. The difference - and perhaps the real target of our critics - is that private enterprise is not adequately involved in the management or engineering of our nuclear plants and hence not in the significant role that private enterprise plays in the United States. We started on a course very similar to the Americans in organizing for the design and construction of our first prototype station at Rolphton, but since then each succeeding nuclear station in the Ontario system has been more and more dominated by either federally or provincially controlled organizations. Fortunately, the federal agencies, the provincial bodies and Canadian industry all realize this situation is not adequate for the future: that industry must have a larger role. But the transition does not yet have clear sailing ahead, as there is little consensus on the most effective industrial re-alignment, on when the pendulum should start to swing back, or how quickly it should swing. The present set-up evolved as an appropriate expedient to satisfy our immediate domestic needs. It is the only vehicle we now have to get a foothold in reactor export activity as there is no other viable group in our country. Industry, through a 1968 CNA resolution, has supported AECL in taking the lead in export promotion until the private enterprise base in Canada has acquired the expertise and a comprehensive role in management, engineering, manufacture, commissioning and servicing of reactor systems.

I think the change should start shortly. The longer it is delayed, the more difficult the transition will be. In nuclear power programs, probably more than others, organizations now tend to get locked in indefinitely.

This comes about because management and engineering become involved on the larger new stations while still contributing to the erection and commissioning of stations started six or more years ago. For example, the on-power shake-down tests of the 200,000 kilowatt Douglas Point Station are still proceeding while the engineering and management teams have already progressed past the design of the 2,000,000 kilowatt Pickering Station and are now engaged on the 3,000,000 kilowatt Bruce Station. It will be an exciting decade as the transition evolves around an expanding export market.

The MacLean-Hunter series of lectures at Expo '67 had a dominant theme running through them - that since the turn of the century, good planning has been the key to successfully applying new technology for the benefit of civilization. And planning the transition of leadership from government groups to industrial groups is the task facing Canada right now. Although only a fraction of the total activity has to be transferred, it must be remembered that it is the key ingredient, and we must effect it while our competitors are already organized to do battle. It cannot be effected quickly - it may take ten years and certainly not less than five - because of the long life span of these programs and the extensive overlap with future domestic and foreign orders. With the federal crown company now a virtual monopoly in the planning and engineering of power reactors, as well as in nuclear research and development, the federal presence and financial support must be continued for many years yet and applied towards supporting this transition to private enterprise if it is to be successful.

Both Conservative and Liberal Governments have continuously, and almost unstintingly, supported our nuclear effort.

In the essays on Federalism and the French Canadian, our Prime Minister said - "We should direct our capital to the key sectors of the future - computers, services and industry in the age of nuclear power." With no disagreement that nuclear power is a key factor in our future - and it can be one of the most significant sectors of our industry in the future - it should continue to get its fair share of financial support.

In looking ahead as to how the heavy water nuclear reactor can best penetrate foreign markets, let me start with some other remarks of Mr. Trudeau. In the essays previously mentioned, he said he believes that the hope of mankind lies in multi-nationalism and quotes Louis Armand as follows: "Before the last war if you had raw materials, manpower, capital and energy, you could be an industrial country, whatever your human or financial potential. This is no longer the case. The only material that counts now is the number and quality of research workers, ceaselessly contributing to the progress of science and technology. Actual needs destroy the idea of nations; they imply - and impose - great industrial complexes and a sharing of manpower, markets and capital. There are no longer any solutions on a national scale." Nuclear energy is one such technologically intensive activity and we cannot remain a viable custodian of know-how in applying heavy water knowledge to commercial use if we apply it only in Canada. Nor would this be a fitting sequel to the one billion dollars already spent by Canada on nuclear research and development - especially in a country where exports are the life-blood of our economy.

In Canada today, our technologically intensive industries - automotive, aircraft, electrical, chemical and petro-chemical - are dominated by multi-national companies.

In the long-run, this will be true for our nuclear industry - it already is that way in the United States, Germany, Italy, France and Japan. Our direct competitors are emerging - both Germany and Britain are now offering heavy water reactors for sale and are having some success by taking advantage of overall trading tactics, even though they lack our background of heavy water reactor technology and proven performance. We shall have to put the Canadian capability into the best possible vehicle in which to meet our foreign competition or we shall be an also-ran.

Before leaving the multi-national corporation, let me make one remark that bears on the White Paper on taxation. Few miss an opportunity to comment on some aspect of the tax proposals and let me be no exception. If technologically intensive areas are to be dominated by international firms - and a recent article in the Harvard Business Review states the current consensus is that multi-national companies are the best vehicle to exploit the flow of technology across national boundaries - then Canada must be ready to accept them and benefit from them. To do otherwise is to stagnate. For a multi-national company to be progressive and worth its salt, it will be active outside Canada to a greater degree than within Canada. A good example is Massey-Ferguson. Our government will have to face up to exercising our national prerogatives on multi-national companies by means other than ownership as the financial resources of our population are too small to control all, or even most, of the technology based companies that will be operating within our borders. But ownership in technology based international companies should be encouraged through tax incentives, not discouraged, as they will be the dominant factor in our future business activity.

This is a better depository for Canadian investment capital than to increase our control through ownership of those companies operating essentially within our own borders, but progressively shrinking in importance. Canada shouldn't jump on the nationalistic bandwagon just when the technological explosion is forcing industry to go international - especially when we have an export-sensitive economy.

To return to nuclear power, the Canadian future is bright indeed. The Canadian beach-head into the peaceful uses of radioisotopes - a by-product of our reactor research program - will continue to grow in both the medical area, such as cancer treatment, and in the industrial area such as in food preservation and quality control. The uranium mining industry, after a few more years of quiescence, maybe only 2 or 3, will again flourish and the world's hunger for power will stimulate a steadily increasing tempo of exploration, mine development and production during the remainder of this century. In the next few years our domestic utility program for reactors will continue to expand and will be the foundation for a growth of export business, including the United States, that will tax our capacity to satisfy. Future success, of course, is not assured. In this case, the extent to which we establish a dominant position in the reactor supply market will depend upon how well we plan and effect over the next few years a transition from a government-led activity into a commercially-oriented international operation. Its full success will provide a tremendous stimulus to the Canadian economy as a whole. It will provide our workers with challenging and rewarding vocations and our scientists and engineers with a purpose in developing new technical tools for an expanding enterprise that will benefit the whole world.