3/74

CANADA'S NUCLEAR INDUSTRY

AN INDUSTRIAL OVERVIEW

FOR

SPAR AEROSPACE PRODUCTS LIMITED

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AN INDUSTRIAL OVERVIEW FOR

SPAR AEROSPACE PRODUCTS LIMITED

PREFACE

The principal object of this report is to assess the real business opportunities for Spar Aerospace Products Limited in the nuclear industry in Canada. What, then, is the nuclear industry in Canada?

Principally, the nuclear industry is centered around the development and efforts of Atomic Energy of Canada Limited; therefore, to understand the industry, it is necessary to fully understand the history, the raison d'etre, and the personality of AECL. AECL today represents a $2 billion investment by the Canadian government. In 1972-73, the continued research aspect alone represented a tax payer burden of $87.0 M, with additional capital investments in excess of $100.0 M.

AECL is a crown corporation created in 1952 by C. D. Howe; an objective was to roll out to private industry as much as possible. Does the management of AECL believe this philosophy? Will Canadian nuclear activities allow for competitive profitable industry? What are we selling in the international market place, and why? These questions will be examined.

The seven key officers of AECL - and their equivalents in Ontario Hydro - are all within eight years of age, all were associated with the nuclear effort in Canada prior to the incorporation of AECL in 1952, and all have a strong background in physics. They each then were involved in the period of C. D. Howe, Sir John Cockcroft, and Dr. C. J. (Jack) Mackenzie. Any company, therefore, expecting to work in the nuclear industry would be advised to have a thorough understanding of the corporation's background, and should furthermore expect a close and personal inter-relationship between the key personalities, all of whom have been responsible for the Canadian nuclear development for the past twenty-two years.

With the above facts in mind, the following confidential assessment of the industry and its people in Canada is made for Spar Aerospace Products Limited.

INTRODUCTION

On June 4, 1962, Rolphton went critical. Canada was in the nuclear power business and a new phase of development in AECL had started. The events that preceded this date are the subject of this chapter.

1.1 EVENTS PRECEDING THE FORMATION OF AECL

The concept that energy could be released from matter through a sustained reaction which altered its nuclear structure was substantiated in Germany and France in 1938-1939. At the time Canada had an active research community, and their work in nuclear physics - especially at McGill - was well recognized. It was here that Dr. Ernest Rutherford, a 'father' of the science, developed nuclear principles.

During the early portion of the War - 1939 to 1943 - Canada's research work in nuclear physics was directed by the National Research Council. It's president, Dr. C. J. (Jack) Mackenzie, was the former Dean of Engineering at the University of Saskatchewan, and came to Ottawa on the invitation of C. D. Howe. Mackenzie was personally interested in nuclear physics, and played a vigorous role in establishing a Canadian program. He retired in 1953, but still leads an active life in Ottawa where he is delighted to discuss Canada's nuclear history.

The potential of nuclear weaponry led to the tri-partite agreement at the Quebec Conference in 1943, where the United States, Canada and Britain agreed to jointly pursue a nuclear program. The British heavy water program had been moved to Canada in 1942; hence, Canada agreed to pursue heavy water moderation, forging a commitment to the developing technology.

At the time, Enrico Fermi was heading up the United States nuclear program and felt the light water moderation to be the most practical development route. The British had all of their heavy water expertise now located in Canada, and the Canadian group, under Dr. G. C. (George) Laurence, had done considerable work on the heavy water process and were very enthusiastic about testing their concepts. The agreement was public recognition of the leavings of the various scientific communities in the three countries.

In 1944 Howe approved the construction of a heavy water nuclear reactor. The project was contracted to Defence Industries Limited (DIL). Defence Industries Limited was the crown corporation that C. D. Howe had created immediately after he became Minister of Munitions and Supply in 1939. DIL undertook contracts to construct and operate plants and facilities oriented to the war effort. They had built Gander Airport, the Shipshaw Hydro-Electric Power Plant, and the NRX Reactor. H. Grenville Smith, the Vice-President of DIL, took over the responsibility. DIL's key personnel had been drawn from the Canadian Industries Limited (CIL), Canada's largest chemical manufacturer and a subsidiary of Dupont and of ICI of Britain. The project, Nuclear Reactor Experiment (NRX), was to be located at Chalk River under the direction of Sir John Cockcroft who had recently come from Britain. All personnel associated with the nuclear program became employees of DIL, including some senior executives of AECL today and people such as L. G. (Lorne) McConnell, now Director of Nuclear Generation and Heavy Water Plants for Ontario Hydro.

Public interest in the concepts of nuclear energy was minimal at the time. This was dramatically changed on August 8, 1945 with the detonation of a nuclear fission weapon at Hiroshima and Nagasaki, abruptly drawing the world's attention to the dramatic and destructive forces that might be realized through the application of nuclear science.

Insofar as Canada was concerned, the immediate result of the end of the War was the exodus of the international nuclear research personnel, including Dr. Cockcroft. Programs to pursue uses of this new technology assumed national priorities. Cockcroft was replaced by W. B. (Ben) Lewis who was to play a vital role in the Canadian nuclear development story.

A TIMETABLE OF NUCLEAR EVENTS [1]

1896	Henri Becquerel discovers radioactivity in uranium compounds
1898	Ernest Rutherford is appointed professor of experimental physics at McGill University, Montreal.
1932	Dr. James Chadwick identifies the neutron, which proves to be a most effective particle for bombarding elements
1938-39	Hahn and Strassmann at Berlin, M. Joliot-Curie and associates at Paris report puzzling effects of bombarding uranium with neutrons. Lise Meitner and Otto Frisch interpret these effects as nuclear fission. Pandora's Box is opened.
1940	First Canadian experimental work on uranium fission begins
1942	World's first nuclear 'pile' operates at Chicago (December 2nd)
1943	A tri-partite agreement is signed at Quebec City between the U.S., the U.K. and Canada for joint action on uranium fission.
1944	Chalk River is chosen for the Canadian work (August 19th)
1945	Canada's first experimental research reactor (ZEEP) goes critical (September 5th)
1947	The reactor NRX started up (July 22nd)
1949	Commitment to a new high flux reactor - National Research Universal (NRU)

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[1] Quoted, in part, from Canada's Nuclear Story by W. Eggleston. Pages 357, 358.

1.2 THE LEGISLATIVE BEGINNING - THE ATOMIC ENERGY CONTROL BOARD

The first legislative step was the creation of the Atomic Energy Control Board in 1946, under the Atomic Energy Control Act, RS, C. 11. The new Board had constitutional authority to control all activities with respect to the development, licensing and control of atomic energy. Under Clause 10 of this Act, it was specifically authorized to create companies under the jurisdiction of the Crown to become responsible for the development of atomic energy itself. The Act also constitutionally removed the control over uranium development from the provinces, giving it to the Federal Government.

> "10. Local Works and undertakings other than such as are of the following Classes: -
>
> (c) Such Works as, although wholly situated within the Province, are before or after their Execution decalred by the Parliament of Canada to be for the general Advantage of Two or more of its Provinces." [1]

General A. G. L. (Andy) McNaughton became the first president of the Atomic Energy Control Board in 1946. In 1939 he had been Jack Mackenzie's predecessor as President of the National Research Council, and subsequently became President of DIL. In 1946 DIL was responsible for the nuclear program at Chalk River, and it was McNaughton who arranged for the Research Council to reassume responsibility for this project. Dr. David A. Keys left his position as Professor of Physics at McGill to become Vice-President of the National Research Council, responsible for nuclear activities and Chalk River. Keys was an acknowledged brilliant physicist, having studied under Wilhelm Roentgen and Sir James Thomson at the Cavendish Laboratories.

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[1] Rünnalls, O.J.C: "The interface between Government and Business in the Uranium Industry". A paper prepared for a seminar May 8-10, 1974, sponsored by the Institute of Public Administration of Canada.

The Atomic Energy Control Board now had jurisdictional responsibility for nuclear activity in Canada. One of the principal areas of concern was the holdings in Eldorado Gold Mines Ltd.

In 1942, the Hyde Park agreement had committed the American, British and Canadian efforts towards building a nuclear weapon. There were only two sources of uranium in the world at the time: the Belgian Congo and Canada. Canada had undertaken to assure a security of supply, under tightly controlled secrecy.

In 1942, to meet this commitment, the Canadian government purchased the stock interest of the Labine brothers in Eldorado Gold Mines Ltd. The government continued to purchase, on the open market, the balance of any stock available, and by 1945, Eldorado was effectively controlled by the government. The company's management had made several agreements with an exclusive agent, Boris Prugell, in which commission rebates not in the best interests of the shareholders of the company were indirectly being paid to the company's management. Grant Glasgow, investigating the foreign exchange areas, discovered this discrepancy, and during October and November, 1945, was commissioned to examine in detail Eldorado's accounts. His recommendation was that C. D. Howe take immediate action; Howe then suggested that W. J. (Bill) Bennett be put in as President. Bennett's first action was to terminate Prugell agreements, and then re-negotiate all agreements pertaining to the supply of uranium with General Groves, who was in charge of the American program. Legal charges were placed, but never executed due to the security needed for the nuclear field.

Bennett remained closely alligned with the nuclear field, subsequently becoming President of AECL, retaining that position until after the second Diefenbaker election. He was a personal friend of John Diefenbaker's, having established a strong rapport during the war-time period. Bennett, on a number of occasions, had tried to break himself loose from the government field, and each time undertook new responsibilities in 1958.

The legislative steps for the Atomic Energy Control Board are set out in a paper by Dr. O. J. C. Runnalls.

1.3 NATURAL URANIUM AND HEAVY WATER - CANADA'S TECHNOLOGY

In the early 1940's membership in the nuclear 'club' was basically held by the United States, Britain and Canada. The Americans were working on light water reactors, the British on graphite moderated reactors, and the Canadians on heavy water. At the time the Americans were the producers of heavy water, and were the only country able to commit sufficient capital resources to institute a program for enriched fuel.

Enriching increases the proportion of U_{235} occuring in the uranium and allows for less efficiency in the moderator. At a critical level no moderator at all is needed for the uranium to sustain a continual reaction. Task Force Hydro, Report Number Three, Chapter 11 gives an explanation of the concepts for the non-technical reader.

American industry can spend sufficient money in development that the country can effectively 'bulldoze' its technology on the rest of the world. This is what has happened in the international nuclear energy field. Countries, however, become loyal to their own technology, and Canada and Great Britain were no exception. It has only been during the last five years, when corrosion problems in the graphite moderated reactors have demonstrated almost insurmountable technological obstacles, that Great Britain has been forced to consider alternatives.

So high is the capital cost of the Magnox stations that the Central Electricity Generating Board (CEGB) estimates that while a pressurized water reactor of the desired size would cost approximately 300 M pounds to build, a comparable Magnox station would cost 500 M pounds. The first AGR is now six years overdue and it will be several years yet before it is contributing power to the grid. Meanwhile, the CEGB is faced with a shortfall of some 35,000 Mw in generating capacity in the 1980's.

The CEGB admires the success of CANDU, but they point to two fundamental matters which encouraged Canada but apparently militate against it in Britain: domestic abundance of natural uranium, and considerable experience in heavy water. In addition, Britain has just entered into the expensive business of developing centrifuge technology with Germany and the Netherlands, in order to have an independent enrichment capacity.

There has been some controversy surrounding the CEGB request that it should be permitted to order light-water reactors of the types which have given the American industry resounding success throughout the world. However, a massive program of light water reactor building can be expected unless some radical and unexpected change occurs in the whole energy equation.

The decision to go to fast reactors of commercial size cannot be taken until the Dounreay prototype has been operating without major problems for at least two or three years.

Canada, however, has met with considerable success in their nuclear program, especially in light of the manpower and expenditures. By 1967, Dr. G. A. (George) Pon, General Manager of Power Projects for AECL, estimated the nonmilitary expenditures and manpower commitment of the four main free world countries with respect to Canada as:

	MANPOWER	TOTAL COST [1]
CANADA	1	1
UNITED STATES	9 - 13	16 - 18
UNITED KINGDOM	5 - 7	3 - 3.5
FRANCE	7 - 10	3 - 4

> Pickering and its results have clearly established the competitiveness in terms of cost, reliability and availability of Canada's technology, which has been achieved at less than 35% of the cost of the three noted competitive programs, and less than 6 1/2% of the American expenditures, utilizing less than 20% of the manpower of the three comparitive programs.

To this must be added a comment of L. R. (Les) Haywood that General Electric in the United States has spent more in development money than has been spent in the entire Canadian program - and this is only one of a number of competitive companies.

The USAEC continued to support a heavy water program through the 1960's, spending $10.0 M in research and development. In 1968 the USAEC dropped this program, as did Sweden even after considerable investment. Canada came close to following suit in 1970; however, by 1974, Canada has demonstrated success, justifying the expenditures on the program.

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1 Pon, G. A: An Introduction to Canada's Nuclear Power Program. Page 8

1.4 THE FORMATION OF AECL, FEBRUARY 14, 1952

By 1951, NRU was under development, commercial possibilities were arising, and the program was growing. Because the National Research Council is not geared to operational projects, or to acting in a commercial fashion, CRNL became difficult to handle managed in this way. Therefore, George Bateman, Bill Scully, and Bill Bennett, all members of the Control Board, agreed to press C. D. Howe for a new crown corporation. Jack Mackenzie was within two years of retiring as the President of the National Research Council. He had to decide between staying on at the Council or moving to AECL as the first President. As Dr. E. W. R. (Ned) Steacie could handle the Council, Mackenzie decided for AECL. In 1952, C. D. Howe, under the authority set forth in Clause 10 of the Atomic Energy Control Act, authorized the incorporation of Atomic Energy of Canada Limited (AECL), a crown corporation responsible for the development of atomic energy in Canada.

Howe envisaged AECL serving an internediary role, passing to private industry those elements which had commercial developmental value.

The actual legal creation of AECL as a separate crown corporation, although significant in retrospect, was less than evident to the employees. The participants in the nuclear research activities moved sequentially from NRC to DIL, back to NRC, and then to AECL. Their immediate environment was unchanged.

The seven senior executives within AECL today were all associated with the nuclear effort in 1952, and most were know to Jack Mackenzie. J. Lorne Gray and Ben Lewis have played key roles since the inception of AECL; John Foster worked for Montreal Engineering, assigned to the NRU project.

The new crown corporation was able to pursue profitable ventures and hence the activities associated with medical therapy. The Cobalt 60 Program was a candidate for the new company.

Radioactive Isotopes

In 1952, Eldorado Mining and Refining Company had a small Commercial Products Division, headed up by Roy Errington, selling radium. Errington's group logically came within the AECL confines.

Radioactive isotopes are created by directing a stream of nuclear particles - readily obtained from thermal reactors - at the material to be irradiated. At the time of the incorporation of AECL, Eldorado, which had become a crown corporation in 1948 with the expropriation of the balance of the outstanding stock, had sixty different types of isotopes being shipped to some twenty-three institutions. Eldorado had made break-throughs in the use of Cobalt 60 for gamma ray treatment of cancer (patented in 1951).

1952 was ended with an incident that almost terminated the nuclear program: NRX overflowed on December 12th. The reactor was shut down for fourteen months, and severe questions were raised. The crisis is well documented by Wilfred Eggleston in Canada's Nuclear Story. The program continued.

1.5 AECL'S SECOND PRESIDENCY, 1953 to 1958

In November of 1953, Willian J. (Bill) Bennett, who was - and continued to be - President of Eldorado Mining, agreed to become the acting President of AECL on the retirement of Jack Mackenzie. Bennett was not a scientist.

AECL had two major divisions: Operations and Administration, under the direction of Lorne Gray, and, Research, under the direction of Ben Lewis. Administration of AECL was handled by Don Watson, Bennett's Executive Assistant; although Watson was trained as a physicist, he was interested in administration. Watson, now Vice-President, Administration, is serving much the same role today. The financial Vice-President of the corporation was Donald (Don) Campbell, now the President of McLean-Hunter.

Nuclear Power

Ben Lewis continued to be the leading advocate of AECL's entry into the nuclear power field. His audience was three visionary engineers who jointly held the key political control that was - and still is - so vital to Canada's nuclear program. This control embraces the Federal government, the Provincial government of Ontario, the client for nuclear energy, and the Federal agency contractually responsible. This is discussed further in 3.2. The men involved at that time were:

1 C. D. Howe

Howe was the most powerful political force, and the person responsible for the program to Cabinet. He understood both the technology and the management requirements.

2 Dr. C. J. (Jack) Mackenzie

Mackenzie is a highly respected engineer, scientist and administrator who was President of AECL, and past President of NRC. He was committed to nuclear power.

3 Richard L. (Dick) Hearn

Hearn was Chairman of Ontario Hydro. He was one of the few chairmen to come up from Head of Engineering through President to Chairman, was convinced that Hydro's future lay with nuclear power, and was respected in the provincial political arena.

In 1953, Dick Hearn sent H. A. (Harold) Smith to Chalk River to chair a task force on nuclear power generation. Smith is credited by many as the man individually responsible for the CANDU Reactor concept and ideas. The results of this study led to a specific project which Hearn and Howe agreed to finance as a joint venture between Ontario Hydro and AECL. The project was labelled Nuclear Power Demonstrator (NPD), and was to be built at Rolphton, adjacent to Chalk River. Harold Smith stayed on at Chalk River to work on the NPD project.

When the NPD project was undertaken, at Bennett's insistance proposals were elicited from industry to participate heavily in the program. Canadian General Electric, Westinghouse, Vickers and Dominion Engineering were each invited to propose financial and operational agreements with AECL, under which they would become the principal contractor for NPD, developing a nuclear expertise. The condition of the proposal was that a contribution must be made to the program; in other words, the party would have a cash commitment against the success of the total program. Canadian General Electric was the only company prepared to make a substantial cash commitment, initially $2.5 M and subsequently about

$2.0 M. Bennett was dismayed with the Dominion Engineering proposal and indicated that the two companies with nuclear expertise - CGE and Westinghouse - were significantly ahead of the other two proposals.

In all of the subsequent interviews, CGE was accorded due credit, and, to the best of our knowledge their reduced nuclear role today is not a result of the performance of client service in their key project roles.

NPD was jointly financed by Ontario Hydro and AECL on a cost-plus basis. John Foster and Lorne Gray went to Peterborough to work with CGE on the project.

Pressure Tubes with Zirconium

1957 saw another major engineering change in the CANDU concept. The United States had been successful using zirconium and steel to develop high temperature strength alloys for their submarine program. Zirconium permitted the development of pressure tubes as opposed to the pressure vessel technique. This decisions was substantiated the next year when the Russians outlined even more effective results with zirconium at the Geneva Nuclear Conference. Pressure tubes and horizontal fueling were both Smith decisions.

In 1957 NRU went critical and Canada was in the forefront of high flux research work and in strong position to produce a wide range of isotopes.

Events of 1958

. . . AECL represented a $100.0 M investment

. . . Two research reactors were operational (one of them having survived a major accident), and a power development was in progress

. . . The Conservatives came into power

. . . Bill Bennett resigned to assume the Presidency of the Iron Ore Company of Canada, a position he still holds today

. . . J. Lorne Gray became President of AECL

. . . Harold Smith became Vice-President, Engineering, of Ontario Hydro

1.6 1958 TO 1962 - DOUGLAS POINT/WHITESHELL

Gray and Smith and their commitment to jointly develop nuclear power, have, in large measure, accounted for the success of the program and its ability to weather crises.

Douglas Point

The first new project was Douglas Point, a 200 Mw * CANDU Heavy Water Power Reactor, for which Gordon Churchill announced Cabinet approval on July 18, 1959. After the decision was announced, AECL moved its engineering division to Sheridan Park.

Douglas Point incorporated the design features of NPD, described by L. W. Woodhead as Canada's knowledge reactor. A new method of fueling was incorporated, allowing for bi-directional fueling with uniform burning and inherent economies.

Smith and Hydro have adhered to the viewpoint that for power generating facilities, the engineer could not be the builder. They have also gone on the general principle that as much construction and material supply as possible should be sought from competitive private industry sources, with the engineering and management held within. Lorne McConnel indicated that this policy arises with Hydro whenever the project becomes beyond the competitive scope of Canadian industry. Canada does not have sufficient resources to support two bidders who could engineer and construct a nuclear plant on a turn-key basis. Britain has discovered that they can only support one; the United States currently supports three or four. For non-competitive situations, the engineering is jobbed and the engineer is not encouraged to bid the total project. This does not hold true for sub-systems or competitive areas open to two or three contenders.

Whiteshell

By the late 1950's, Chalk River was approaching maximum size for efficient operation. A second Chalk River was to be established near Pinewa, Manitoba, and this facility, with its capital commitment of an additional $60.0 M, was made in 1959.

1962 - A Milestone Year

Several significant events happened coincidentally in 1962 which made it a turning point year in the evolution of nuclear power:

1 It was decided to make Whiteshell an organic material cooled reactor. CGE was awarded the task of designing the reactor.

In all Canadian experiments until this time, the coolant had been heavy water, which has a low boiling point. Theory dictated that if organic coolants such as oil were used, the thermal to electrical efficiency could be improved. Under water cooled reactors, the thermal to electrical efficiency runs between 30 and 33%; organic cooled reactors presently exhibit efficiencies of between 36 and 38%.[1] Actual efficiencies have exceeded 40%, which decreases the fuel required to produce rated power.

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1 AECL Annual Report 1969

AECL 1974

A SIGNIFICANT ASSET

INTRODUCTION

In 1974, Atomic Energy of Canada Limited represents a cumulative Canadian investment of 2.0 billion dollars; a net asset (balance sheet) of $906.0 M; and, a current annual expense to the taxpayers of $200.0 M.

This level of commitment demands a continual political focus. Without this involvement of public funds, Canadians would not have their nuclear industry. Every new commitment is subject to multi-government involvement.

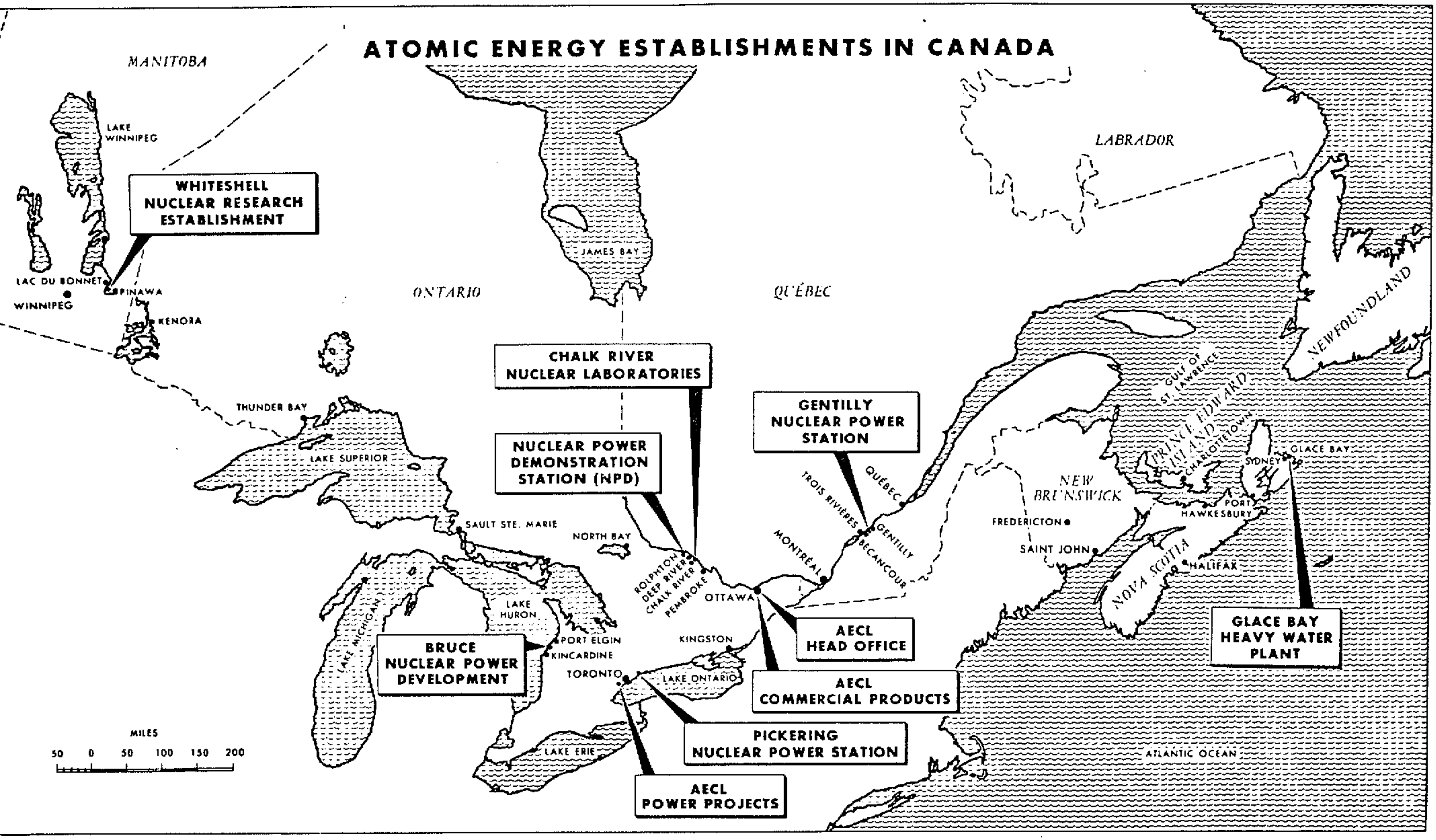
Nuclear developments take considerable time. The period between commitment and operation of a reactor is six to ten years; the life of an average Minister of the Crown in the 1970's is two to three years. It is difficult, therefore, to sell the benefits of a nuclear program to a politician - or even to a political party.

If it were not for the commitment, political durability and vision of Dick Hearn and C. D. Howe, it is unlikely a nuclear programme with its own technology would exist in a country the size of Canada. As a result of the momentum created by the, AECL has, within limits, been able to pursue the program proposed with the support of the Government in power.

However, the political attitude to the nuclear program has oscillated. In 1970, with the Glace Bay disaster, Douglas Point in trouble, and Pickering not started, G. E. (George) Gathercole, Chairman of Ontario Hydro from 1961 to 1973, favoured terminating the total program. Harold Smith prevailed and the level of commitment continued.

In 1974, Pickering has proven unbelievably successful; the CANDU Reactor, based upon a proven 80% net capacity, is clearly cost competitive with alternative technologies; and, the soaring prices of fossil fuel - and public pressures against its use for power generation - have given strong financial and political impetus to nuclear programs. The Canadian nuclear community has a right to be intensely proud.

The milestones leading to this position, and the make-up of AECL today, are the subjects of this chapter.


ATOMIC ENERGY ESTABLISHMENTS IN CANADA
MANITOBA
LAKE WINNIPEG
WHITESHELL NUCLEAR RESEARCH ESTABLISHMENT
LAC DU BONNET
PINAWA
WINNIPEG
KENORA
ONTARIO
JAMES BAY
QUÉBEC
LABRADOR
NEWFOUNDLAND
CHALK RIVER NUCLEAR LABORATORIES
NUCLEAR POWER DEMONSTRATION STATION (NPD)
GENTILLY NUCLEAR POWER STATION
THUNDER BAY
LAKE SUPERIOR
SAULT STE. MARIE
NORTH BAY
ROLPHTON
DEEP RIVER
CHALK RIVER
PEMBROKE
OTTAWA
MONTRÉAL
TROIS RIVIÈRES
QUÉBEC
GENTILLY
BÉCANCOUR
GULF OF ST. LAWRENCE
PRINCE EDWARD ISLAND
CHARLOTTETOWN
NEW BRUNSWICK
FREDERICTON
SAINT JOHN
NOVA SCOTIA
HALIFAX
PORT HAWKESBURY
SYDNEY
GLACE BAY
GLACE BAY HEAVY WATER PLANT
LAKE MICHIGAN
LAKE HURON
BRUCE NUCLEAR POWER DEVELOPMENT
PORT ELGIN
KINCARDINE
TORONTO
KINGSTON
LAKE ONTARIO
AECL HEAD OFFICE
AECL COMMERCIAL PRODUCTS
PICKERING NUCLEAR POWER STATION
AECL POWER PROJECTS
LAKE ERIE
ATLANTIC OCEAN
MILES
50 0 50 100 150 200

2.1 MAJOR MILESTONES OF THE 1960's

1 Pickering - 1964

In 1964, less than two years after the start up of NPD, and three years before the 200 Mw. prototype at Douglas Point produced its first electricity, Ontario Hydro committed for a 1,000 Mw plant at Pickering, three miles east of the border of Metropolitan Toronto. Studies during 1963 and 1964 had concluded that for nuclear power to be competitive to thermal stations, plants in the order of 450 to 500 Mw would be required. Pickering was to be engineered by AECL as a stepped up version of Douglas Point.

At the Geneva Conference of 1964, Ben Lewis and T. G. (Tom) Church forecast 5,000 to 7,000 Mw of CANDU nuclear power in Canada by 1981.

2 USAEC Contracts for OCR Facilities at Whiteshell - 1964

The USAEC launched a major OCR research program in 1964, contracting directly with AECL for the use of an organic loop in NRU and 50% of the use of WR1. This encouraged our OCR program plans. Whiteshell went critical in 1965.

In 1972, the estimate to continue Canada's OCR program with a full-scale reactor was $500.0 M: for financial reasons, the program has been terminated.

3 Gentilly - 1965

In 1965 AECL announced a joint venture program with Hydro Quebec to develop a 250 Mw boiling light water (BLW) version of CANDU. Boiling light water offered heat transfer efficiency, the elimination of heat exchangers, and economies.

4 Fuel System Redesign - 1966

In 1966, a major redesign of the fuel system for NPD was undertaken and contracted to CGE. The on-line refueling and the reliability of the fueling system were significant to CANDU production.

5 200 Mw On-Line - 1967

Douglas Point started generating electric power in 1967, giving Canada its second 'knowledge' generator.

6 Bruce - Heavy Water and Reactors - 1968

The heavy water program was in serious trouble in 1968. Ontario Hydro had relied upon from Deuterium of Canada, and Deuterium's failure placed the nuclear program in jeopardy. AECL was authorized to build an 800 ton-per-annum heavy water plant at Bruce, with completion scheduled for 1972-73.

Ontario Hydro announced a further commitment to the nuclear program with Bruce (1 - 4) and 3,000 Mw of electric power. AECL was to be the project engineer. NPD was converted from (PHW) to (BLW).

7 Canadian General Electric Backs Out - 1968

Canadian General Electric withdrew, in 1968, from the engineering and marketing fields. In 1953, CGE had been the original engineers on the NPD project, and had been the marketing agents and engineers for the international CANDU market. Their only success was the Karachi Electric Supply Corporation in West Pakistan; their engineering and marketing program was a liability. Ontario Hydro's reluctance to allow CGE to participate as an engineer - and Hydro being the only major client for CANDU - created conflicts. CGE used a vertical design as opposed to the horizontal design employed by AECL, and the resultant fueling efficiencies gave a technical reason for CGE to withdraw.

AECL personnel emphatically point out that they did not force CGE's withdrawal. Certain animosities within CGE still exist. The evidence would appear to indicate that there was no room for two design engineering groups to be supported by the CANDU program, and international sales were not - nor would they be - such as to warrant an independent group conducting this marketing. CGE lacked financial depth, and the parent would not provide help. This aspect is further explored in 3.6.

Effective July 1, 1968, AECL assumed responsibility for the CGE engineering group, which was merged with AECL Power Projects under terms of agreement between the two companies. AECL attained responsibility from the Canadian Government to engage in the export marketing of Canadian nuclear power stations, the original efforts to be directed by A. M. (Archie) Aikin.

8 Taiwan - 1969

The first - and, in fact, the only - major, independent sale of the Nuclear Power Marketing Division of AECL was to the Republic of China, Taiwan, in 1969. The sale involved an updated version of NRX, the design, building and sale of all the significant components, and the training of personnel associated with the reactor. Engineering and management were handled by Canatom Ltd.[1] Taiwan represented a net of $28.0 M in cash business to Canadian industry.

9 Crisis to Success - 1970

1970 represented a critical year in the Canadian nuclear program with a move to abort at the beginning of the year. By the end of 1970, the program was bolstered by Gentilly going into operation on November 12th, within days of its original target date. Steam was produced in the first of the Pickering reactors - also within a fortnight of the schedule set at the end of 1967.

Events of the 1970's can hardly be constituted as milestones as it is difficult to review them in perspective. The success of the program by this time is best illustrated by L. W. Woodhead, Manager of Nuclear Operations at Ontario Hydro, in a paper given by him to the fifth Foratom Congress, Florence, Italy, on October 15, 1973. The paper is entitled Canadian Commercial Nuclear Electrical Experience, and outlines the reasons for success of the Pickering program.

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[1] Canatom Ltd. is Canada's only consulting engineering company wholly specializing in nuclear engineering. It is owned jointly by Montreal Engineering Company Limited, Shawinigan Engineering Company Limited, and Surveyer, Nenniger & Chenevert Inc.

2.2 AECL ECONOMIC PERFORMANCE 1968 TO 1973

From a financial analyst's viewpoint, Atomic Energy of Canada Limited would possibly represent the most static corporation in Canada. In financial terms it lacks 'market pizazz'; technologically however, it is unique and perhaps represents a significant untapped potential.

By the middle of the 1960's, the following had occurred:

1 Chalk River, under Les Haywood, had the research reactors (NRX and NRU) running efficiently with a stable and near-capacity research program. NPD was operational at Rolphton, producing electric power using the CANDU/Smith ideas.

2 The Power Projects Division at Sheridan Park, under the direction of John Foster, was working on Douglas Point and Pickering.

3 The Commercial Products Division, under Roy Errington, had reached a sales level of $7.0 M, nad Canada was well recognized for its pioneering and technological leadership - especially with respect to the Cobalt 60 program.

4 The Whiteshell Nuclear Research Establishment had been approved and, under the guidance of A. J. (Ara) Mooradian, construction was underway.

Since 1964, significant events that would normally affect the level of employment of a company, scope of activities, and its demand for financing were as follows:

1 Whiteshell was opened in 1965

2 The Commercial Products Division opened a new office and expanded facilities in South March in 1968

3 The CGE Engineering Branch and international marketing responsibilities were both absorbed into Power Projects

4 Technology exchange agreements were signed with Japan, France, India (Rajasthan) and Pakistan (Kanupp), all of which required additional personnel

5 Power Project engineered four 500 Mw generating stations at Pickering (1967), and an additional four 750 Mw generating stations at Bruce (1968)

6 Hydro Quebec contracted for engineering to build Gentilly, a 250 Mw (BLW) Reactor

7 The sale of the NRX Reactor to Taiwan ($35.0 M, 1969)

8 The Bruce Heavy Water Plant was managed and financed

9 Power Projects bid in Mexico, Romania, South Africa and Australia, and was successful in Argentina

What was the Corresponding AECL Growth?

1 Research Appropriation from the Government of Canada

In 1968, AECL appropriated $57.0 M in support of research. By 1973, this had moved up to $68M, giving a compound annual growth of less than 3.5%.

2 Personnel

In 1967, the total personnel in AECL was in the vicinity of 4,700, with approximately 1,000 being professional. As of the present, AECL has approximately 4,700 people, around 1,000 of whom are professional - a growth characteristic admirable in light of current government trends.

3 Commercial Products Sales

In 1968, the Commercial Products Division had reached an international sales volume of some $9.3 M per annum; by 1973, an annual sales volume of some $10.8 M had been achieved - a growth rate of three percent per annum. The static nature of sales within this division, despite the development of many interesting and internationally heavy potential products, is a subject of further examination in Chapter Four. The trend for profit and sales was sharply broken in 1973-74.

It is consistent throughout the company that the growth characteristics are practically horizontal in a time and period in which the total international market place has taken many rather severe gyrations. This, in itself, is a reflection on the individuals at the helm of AECL, as well as on the nature of their business. The static level contrasts to the demand surges exhibited in private industry for nuclear equipment on projects where AECL is the engineer. It reflects imbalance of risk-reward and constraints of government financing.

When commenting on this attitude on May 10, Haywood expressed a very serious concern about the direction of AECL's development, a direction that has been forced upon them through the constraint of government financing. In effect, AECL is 'making do' with a fixed capital expenditure, with an ever-increasing requirement to support expanding levels of direct programs. In order to accomplish this, AECL has had a continual shifting of personnel out of long-range research and development into directly servicing the commercial establishments. Haywood made some estimates of how serious this trend has been:

SHIFT OF SCIENTIFIC PERSONNEL ALLOCATION AT CRNL

	1964	1973
Research	25%	20%
Service to Existing Programs	15%	55%
Development for long-range needs	60%	25%

L. G. (Lorne) McConnell of Ontario Hydro expressed similar concerns about the programs of both Hydro and AECL having greatly degenerated in development expenditures, especially in light of the capital commitments Canada will be expending. This is discussed in more detail in 4.2

2.3 THE ORGANIZATIONAL MAKE-UP OF AECL

With AECL it is better to examine the nature of the industry and its people, before becoming concerned with physical responsibilities.

It has been noted that within the hierarchy of AECL, most of the officers are trained in chemistry or physics, all were associated with the atomic energy program prior to 1952, many came from small towns, and most had experience with the Canadian Navy.

A few other observations are warranted. Canada's nuclear expertise was concentrated inside Ontario Hydro, AECL and Canadian General Electric. Many of the senior people have worked for two or three of these organizations. Les Haywood noted that the total senior management and scientific employees at all levels of the Canadian nuclear program, equated to one project in either the United States or Britain. In Britain, with thirty-five to forty thousand people engaged in nuclear activities, the scope almost became unmanageable. The Canadians, working in small teams and observing objectively the total programs of other countries, were able to look at the broad scope and pinpoint the highlights. Thus the Canadians often knew more about the major countries' work in various nuclear fields than did the scientists from these countries. Haywood also pointed out that the incidence of people from small towns was due to engineers from universities such as Saskatchewan being inherently attracted to places such as Chalk River; University of Toronto or McGill engineers found these working and living conditions less palatable. Similarly, small town engineers were less likely to 'project hop', being quite content on a long-term development project.

These factors weigh in the characteristics of the people engaged in the Canadian nuclear program.

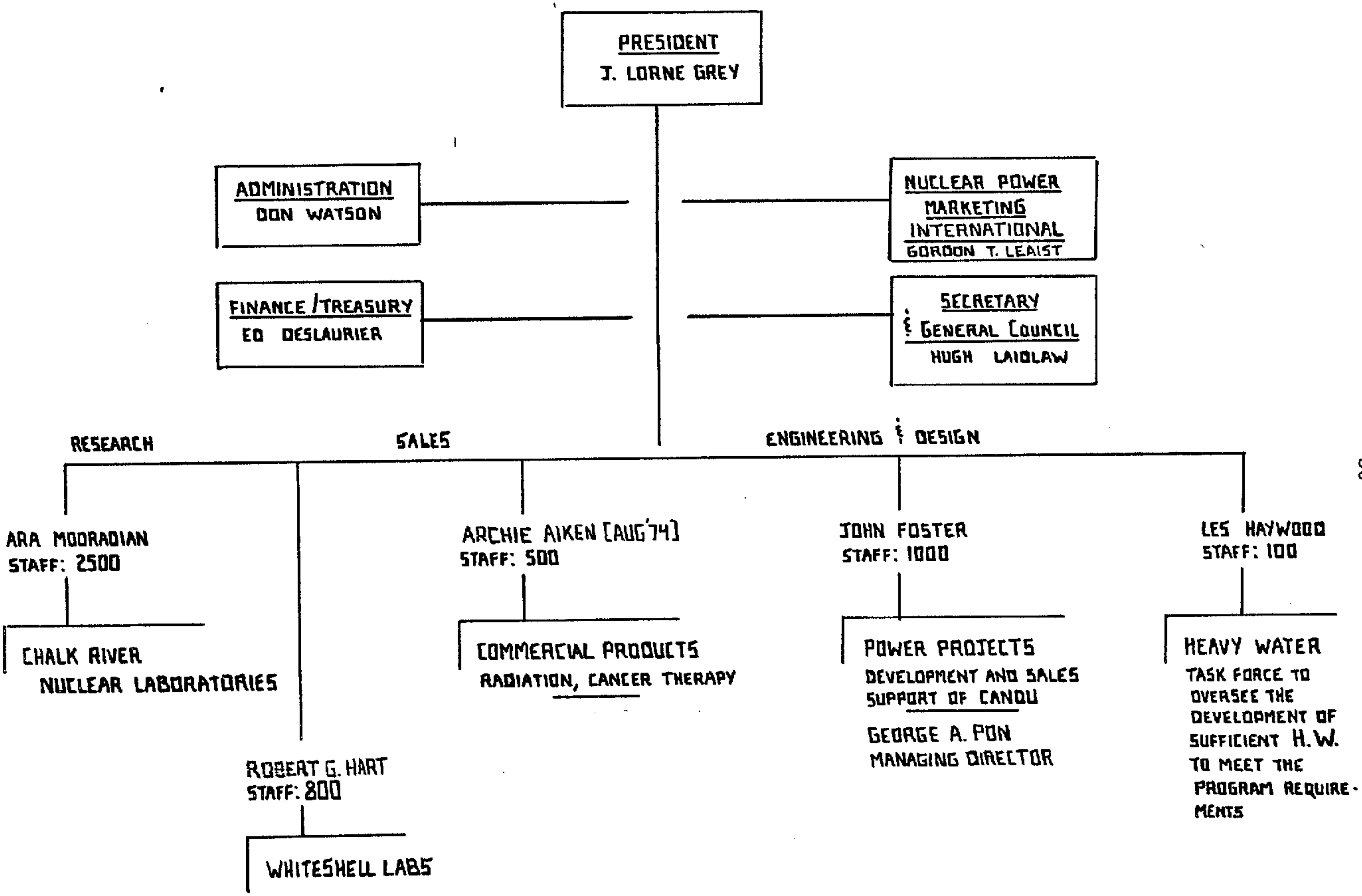
When observing the AECL organization chart, it is well to consider only two segments: Commercial Products, and the balance. All senior employees have had extensive work at CRNL, most have been intimately engaged in the engineering development work of Power Projects, and all had an association with almost every major development of the corporation. There is a rapid and broad level of consultation before any decision is entered into.

Haywood further commented that the group itself had often questioned whether this corporate intimacy was an asset or a liability for the Canadian nuclear program.

The following is an organization chart and a list of the current senior executives with AECL. It should be noted that Archie Aikin has already committed to take over Commercial Products with the retirement in July of Roy Errington. It is also speculated that John Foster is being groomed to assume the presidency upon Lorne Gray's retirement within two years.

Appendix I contains a brief resume on each of the current executives.

ATOMIC ENERGY COMPANY LIMITED



TOTAL A.E.C.L. STAFF	4500
PROFESSIONAL STAFF	1100

APRIL 1974

ATOMIC ENERGY OF CANADA LIMITED

DIRECTORS 1973 - 74

FERNAND BONENFANT, S.M., B.Ph., B.Sc., Ap., M.Sc., Head, Physics Department, Laval University, Quebec City

H. M. CARON, L.s.c., C.A., Partner, Clarkson, Gordon & Co., Partner, Woods Gordon & Co., Montreal

* Y. F. DeGUISE, Commissioner, Quebec Hydro-Electric Commission, Montreal.

G. E. GATHERCOLE, M.A., LL.D., Chairman, Ontario Hydro Corporation, Toronto

* D. A. GOLDEN, LL.B., President, Telesat Canada, Ottawa

* J. L. GRAY, C.C., M.Sc., D.Sc., LL.D., President, Atomic Energy of Canada Limited, Ottawa

C. A. GRINYER, Consulting Engineer, Caledon, Ontario

NANCY E. HENDERSON, Ph.D., Associate Professor of Zoology, University of Calgary, Calgary

A. J. O'CONNOR, B.Sc., General Manager, New Brunswick Electric Power Commission, Fredericton

* H. G. THODE, C.C., M.B.E., Ph.D., F.R.S., Professor of Chemistry, McMaster University, Hamilton

* F. C. WALLACE, D.S.O., M.C., Vice-Chairman and Director, Fiberglas Canada Limited, Toronto

* Executive Committee

ATOMIC ENERGY OF CANADA LIMITED

OFFICERS 1973 - 74

J. L. GRAY, C.C., M.Sc., D.Sc., LL.D.	PRESIDENT
A. M. AIKIN, Ph.D.	VICE-PRESIDENT
R. F. ERRINGTON, M.A. (retires July, 1974)	VICE-PRESIDENT Commercial Products
J. S. FOSTER, B.Eng., D.Eng.	VICE-PRESIDENT Power Programs
L. R. HAYWOOD, M.Sc.	VICE-PRESIDENT Heavy Water Projects
A. J. MOORADIAN, Ph.D.	VICE-PRESIDENT Chalk River Nuclear Laboratories
R. G. HART, B.A.	MANAGING DIRECTOR Whiteshell Nuclear Research Establishment
D. WATSON, M.A.	VICE-PRESIDENT Administration
E. DESLAURIERS, C.A.	TREASURER
A. H. M. LAIDLAW, B.A.	SECRETARY and GENERAL COUNSEL

2.4 INTERFACES TO INDUSTRY

A company interfacing to a corporation such as AECL must ensure that contact is established in several key areas to maintain a total perspective.

When interfacing to AECL, it is important to remember that most senior executives and officers have a tight working relationship. Listed below are a few of the key people within Atomic Energy of Canada Limited.

Executive Liaison

1 J. Lorne Gray

Gray, the President of the Company, is highly approachable and should be made aware of any company's direct interest in nuclear activities. He is the major salesman of Canada's nuclear efforts, representing AECL and Canada on an international basis, and should be know by senior officers of any company wishing to do significant work within the nuclear spectrum.

2 John Foster

Foster is the second major salesman of the company and will, in all likelihood, be the next president. He also represents Canada on an international basis in a manner that could be beneficial to companies having expertise or products to offer. He should be used for sales forecasting in the domestic field, as he keeps an updated assessment of the probability of each of the utilities utilizing AECL. Titularly, Foster is still Vice-President, Power Projects; functionally, he is acting in a management capacity.

Advice

A company that is specifically interested in developing a product or an idea, or wants to test the competitiveness of entering a specific field, would be well advised to contact Les Haywood, Vice-President, Heavy Water Projects. Haywood will give a crisp assessment, an evaluation of the dollars necessary to establish a market, and will probably assist in setting up interviews to bring this about.

Insofar as non-involved advice is concerned, either Jack Mackenzie or Ben Lewis should be approached. They are both retired and live in Ottawa. Ben Lewis could be open to consultative work in planning and development in the nuclear field.

Guidance and Assistance

The task of industry liaison is presently handled by G. Willis (Fletch) Fletcher, who works on staff to Don Watson, the Administrative Vice-President. Fletcher was formerly a physicist at CRNL, and then worked under Archie Aikin in marketing. He knows most aspects of the program and can be reached through head office. It is his responsibility to ensure that AECL is aware of all companies wishing to supply products oriented to the nuclear industry, and that he, personally, is appraised of the technical capability and availability of these products.

Market Forecasting

Domestic market forecasting can be provided by either John Foster or George Pon. Canadian forecasting principally

Within AECL, the people responsible for (1) and (3) are:

AECL Purchasing

An industry's learning curve in nuclear technology can be substantially enhanced through attaining mission-oriented research and development contracts. Therefore, it is important to establish a working relationship with Tom Church, the Administrative Vice-President of CRNL. Church is responsible for assessing the capabilities of industry to meet research needs, and for awarding research and development contracts. He also awards contracts within the university field, keeping a knowledge of nuclear programs at universities, the students and their capabilities (a good source of employees).

Most of this work is tendered; however, there are times when a job might be required, and if Church is not aware of an industry's interest or ability, it might not surface. Church will also entertain an approach from industry for financing to do specific research or development that might be necessary.

Purchasing Agents

H. D. (Harold) Schultz is Head of Purchasing at CRNL;
M. G. (Max) Allan is Head of Purchasing at Whiteshell; and,
G. P. (Gerry) Robillard is Head of Purchasing, Commerical Products, at South March.

In the Product Development Division at Chalk River, both E. C. W. (Eric) Perryman, Director of Development, and G. C. (Geoff) Hanna, Director of Research, should be contacted. Hanna handles basic research such as accelerators and advanced physics. The industrial contracts requiring development work come under Perryman's jurisdiction.

Power Project's International Contracts.

The major contractural work which influences industry will be bids in which AECL Power Projects is designated as the prime engineer and contractor on the job. In this capacity they will be acting in exactly the same manner as a utility, purchasing the majority of components from within Canadian industry. (If the project is funded through EDC, this is an 80% mandatory requirement.)

The two principal contacts from a management and directorship basis are G. A. (George) Pon and G. L. (Gordon) Brooks. A working relationship with Pon is equally important to establishing one with Gray and Foster.

Within Power Projects, W. S. (Bill) Philip is Head of Contracts; he maintains a bidder's list on equipment. He also maintains the full manufacturers contracting and procedural specifications, providing, in Toronto, the analogous function to Fletcher.

Nuclear program. AECL looks to their international sales as a way of adding a few more contracts for Canadian suppliers, making them better able to maintain a continuous production facility and hence, to more economically supply the domestic market.

Because of the performance guarantees that the host country is looking for - and which must come from the Canadian government - Gordon Leaist is of the specific opinion that a Canadian marketing consortium of interested suppliers would have difficulty in selling itself. These guarantees are only acceptable from an organization with financial and technical debth; AECL or a multi-national such as General Electric or Westinghouse are the only organizations with these qualifications in the international market place. Financing is done by EXIM Bank or EDC for Canada, and is not integral to the manufacturer or operator.

The international market place and Canada's sales strategem are further explored in 3.6.

2.6 THE FINANCING OF AECL

The financing of the Canadian research and development nuclear effort is principally done by the Government of Canada through the Ministry of Energy, Mines and Resources. Both capital appropriations and research grants are handled through the Ministry by allocation, Orders-In-Council, or approval by Parliament, depending on the order of magnitude of the financing required. For this reason, major projects are continually open to political scrutiny.

Power reactors are sold to power companies (utilities) and are financed by them. Domestic reactors are financed by the Provincial utility responsible. Foreign reactors usually require assistance from the Government of Canada. The following are levels of funding sources as they currently exist.

1 Research

AECL is engaged in a wide spectrum of research projects principally located at Chalk River Nuclear Laboratories and Whiteshell Nuclear Research Establishment. There is also some radiation chemistry and isotope research, and a few small pure research projects located in Peterborough and Sheridan Park. (See 2.8)

2 Development

Development, as opposed to research, pertains to the refinement of designs and processes for future use. It usually involves known projects, and should be related to an understood level of expenditure at some future date.

Research and Development were initially the major responsibilities of AECL, and continue to play a significant role. Their combined annual commitment, including depreciation against purchased assets and the operational requirements for all research facilities, is slightly over $70.0 M. The research and development appropriation from AECL over the last seven years has been effectively static.

3 Capital Appropriations - Based on the 1973 Annual Statement

AECL has requested from the Government of Canada certain capital appropriations to fund projects within Canada, as follows:

	Millions of Dollars
CRNL, including the NRX and NRU Reactors, land, services and buildings	$156
Whiteshell Research facilities, including lands, buildings, WR1 Reactor, machinery and equipment	$ 56
Rolphton - the AECL portion of the joint venture costs to finance the NPD Reactor	$ 26
The Douglas Point Generating Station	$ 78
The Gentilly Nuclear Power Station	$ 90
The Bruce Heavy Water Plant and the auxilliary steam plant	$203
The Nelson River Transmission Line	$200
Power Projects, engineering buildings, development laboratories, machinery and equipment	$ 14

Commercial Products Division in Ottawa - lands, buildings and equipment		$ 18
Housing projects for Deep River and Pentawa		$ 6
	TOTAL	$850

The 1974 total is $908.0 M. Each of the loans are financed by the Government of Canada, each represent an Order-In-Council, and are provided in one of the following ways:

As a non-capital grant and carried at full book value as a non-depreciating asset;

As a research grant and written off through research funding;

As a 25-year capital loan to be repaid out of project revenues, carried at government interest.

Power reactors are financed by the utilities. AECL financing is a political vehicle. In the heavy water plant at Pickering, after considerable waiting for some shared costs, Ontario Hydro finally proceeded on its own.

However, in January of 1974, the Minister of Energy announced that to promote the CANDU program, Federal government assistance to 50% would be available for provincial CANDU power plants.

4 International Financing

In major resale of technical goods and services, most countries look to financial accomodation from the selling country. The Republic of China (Taiwan) was unique in its cash acquisition of the Taiwan Research Reactor. Both the Indian and Pakistan facilities required accomodation by the Canadian government through the Economic Development Corporation (EDC). EDC makes available on a 25-year loan money up to 90% of the Canadian content contractural value of any agreement. This is specifically to encourage the purchase and acquisition, through Canada, of both expertise and manufactured goods. The majority of the components for both these reactors were thus acquired through Canada.

The Economic Development Corporation is associated with the Department of Industry, Trade and Commerce. An application is made from the purchasing (host) country directly to EDC for financial assistance; such application is reviewed and adjudicated. In current international politics, it unfortunately often matters more who the requesting country is in social rather than economic terms.

Modest grants for research are possible through CIDA.

5 Commercial Products

The Commercial Products Division of AECL is self-supporting, including sufficient revenues to allow full depreciation of buildings, land, and services. These are currently being carried at $700,000. per annum.

6 Power Projects, Sheridan Park

The majority of power project cost allocation comes under development; as such, the capital appropriations are written off under research and development grants.

They do, however, allocate $2.5 M as the engineering building, of which they carry $.13 M per year for depreciation. The Engineering Division should expect to show an operating profit from revenues derived for the design of nuclear reactors.

Power Projects currently operates at a gross expenditure of $22.0 K; their revenues exceed $20.0 M. They bid both domestic and international prospects at cost plus 15%, and maintain a $2.0 M independent development program. They also do several no-revenue projects for corporate offices. They are carrying buildings of $2.5 M, at a $130.0 K per annum rate. It is expected that they will achieve an operating profit position.

7 University Grants

AECL oversees a number of research projects within the university spectrum. In 1972-73 there were forty-one research and development contracts in force at sixteen Canadian Universities, with expenditures amounting to $760.0 K. During 1972, 130 university students were employed during the summer at AECL sites, most of whom were doing work with a direct bearing on their university training.

2.7 RELEVANT FEDERAL BODIES

The Atomic Energy Control Board

The Atomic Energy Control Board was created in 1946 by the Atomic Energy Control Act, R. S., c. 11, s. 1. Under Section 3 of the Act, it constitutes a body called the Atomic Energy Control Board for the purposes of conducting research and investigation with respect to atomic energy, utilization of atomic energy, purchase, lease, requisition or expropriation of mines, deposits or claims, or patent rights relating to atomic energy, and, sell or otherwise dispose of discoveries, inventions or improvements, collecting royalties and fees as payments.

The Board is presently set up under the presidency of D. G. Hearst, and sees itself as controlling the health, safety and security aspects arising from the activities related to the use of atomic energy and equipment. This is done through a comprehensive licensing system, administered by the Board and its staff. The Board has seven major committees pertaining to reactor projects, heavy water, health physics, nuclear material, nuclear equipment, and waste management. There is a small permanent staff, with operational costs in the order of $1.0 M per annum. In addition, the Board oversees $8.0 M per annum in research and development money, allocated by the Federal Government for research in matters associated with the control of atomic energy. The act specifically authorizes the Board to award grants for basic and applied research in atomic energy.

ATOMIC ENERGY CONTROL BOARD

BOARD 1973

DR D. G. HURST	President, Atomic Energy Control Board, Ottawa
PROFESSOR L. AMYOT	Director, Institute of Nuclear Engineering, Ecole Polytechnique, Montreal
DR. W. G. SCHNEIDER	President, National Research Council, Ottawa
MISS SYLVIA FEDORUK	Director of Physics, Saskatchewan Cancer Commission, Saskatoon, Saskatchewan

COMMITTEES 1973

COMMITTEE: Reactor Safety Advisory Committee (Ontario Projects)

CHAIRMAN: Dr. D. G. Hurst

MEMBERSHIP:
Government: 10
AECL: 5
University: 1

COMMITTEE: Reactor Safety Advisory Committee (Gentilly)

CHAIRMAN: Professor L. Amyot

MEMBERSHIP:
Government: 7
AECL: 6
University: 2

COMMITTEE:	Safety Advisory Committee for Glace Bay Heavy Water Plant and Point Tupper Heavy Water Plant
CHAIRMAN:	Mr. J. H. Jennekens (Acting Chairman)
MEMBERSHIP:	Government: 6 AECL: 2
COMMITTEE:	Safety Advisory Committee for Bruce Heavy Water Plant
CHAIRMAN:	Mr. J. H. Jennekens (Acting Chairman)
MEMBERSHIP:	Government: 11 AECL: 2
COMMITTEE:	Safety Advisory Committee for Port Hope Uranium Hexafluoride Plant
CHAIRMAN:	Mr. C. J. Macfarlane
MEMBERSHIP:	Government: 9 AECL: 1
COMMITTEE:	Reactor Operators Examination Committee
CHAIRMAN:	Mr. J. H. Jennekens
MEMBERSHIP:	Government: 3 AECL: 3
COMMITTEE:	Accelerator Safety Advisory Committee
CHAIRMAN:	Dr. L. B. Leppard
MEMBERSHIP:	Government: 8 University: 1

N.B. It should be noted that no committee of the Atomic Energy Control Board contains any representative of Canadian industry.

The present members of the Board are Dr. D. G. Hurst, Professor L. Amyot, Dr. W. G. Schneider, and Miss Sylvia Fedoruk. Information and assistance can readily be obtained through R. W. (Bob) Blackburn, Secretary to the Control Board. The Board reports directly to the Minister of Energy, Mines and Resources.

Energy, Mines and Resources

The Minister of Energy, Mines and Resources is directly responsible for the affairs of Atomic Energy of Canada Limited, the Atomic Energy Control Board, the National Energy Board and Uranium Canada. As such, he must review and recommend to Parliament proposals submitted from these organizations. In order to accomplish this, he maintains a consultative staff that is headed by Dr. O. J. C. Runnalls, Director of Energy Development; Dr. Runnalls reports to W. H. (Bill) Hopper, the Assistant Deputy Minister.

Dr. Runnalls maintains a staff of four for the purpose of policy directive matters. His principal area of concern at present is maintaining policies to encourage the development of uranium reserves. Dr. Runnalls is most approachable and knowledgeable in all fields of nuclear activity; he and his staff are very much of the opinion that Canada is endowed with considerable reserves of uranium, for which the surface has only barely been scratched. To maintain a position as a principal exporter of uranium, Dr. Runnalls is of the opinion that it might be necessary to produce enrichment facilities. (See 4.4)

Eldorado Nuclear Limited

Eldorado is a crown corporation whose assets were expropriated by the Federal Government in 1944; 1948 saw the creation of the corporation under the jurisdiction of the Atomic Energy Control Act. The basis for the original expropriation was the need to guarantee a security of supply, and arose out of a number of incidences between 1943 and 1948 involving the international activities - or lack thereof - of the senior management of this company. The corporation was the government vehicle for stockpiling uranium.

The principal operation of the corporation is at Beaver Lodge, Saskatchewan. In Port Hope, Ontario, Eldorado has a refining plant as well as the only facility in Canada for producing uranium hexafluoride (UF_6). They have offices at Tunney's Pasture in Ottawa, and an association with the AECL offices. Under the presidency of W. M. (Bill) Gilchrist, the company sustained a $3.6 M net loss on operating revenues of $9.7 M in 1972. With the price on the open market going from $4.00 - $5.00 per pound to $13.00 - $15.00 per pound, this situation will turn around sharply in 1974 and 1975.

The National Research Council

The National Research Council is engaged in multi-faceted levels of applied and pure research. It was under this jurisdiction that the initial work in the atomic energy field was initiated. With the incorporation of AECL, the majority of work associated with atomic energy passed to

AECL: however, certain aspects of research in physics still occupy areas of joint and mutual interest, and there continues to be an exchange of personnel and use of facilities between CRNL and NRC. The Research Council previously reported directly to the Chairman of the Privy Council; at the present time reporting is made to a named Minister, C. M. (Bud) Drury.

The National Energy Board

The National Energy Board was incorporated by Parliament in 1959, and its main function is performing regulatory and advisory functions on the transport of energy on an inter-provincial or international basis. Specifically, it is responsible for the issuances of licenses for the export or import of gas or power, the regulations of rates, tolls and tarrifs, and the authorization of construction of inter-provincial and international pipelines or power lines.

The National Energy Board, under the Chairmanship of Marshall Crowe, reports to the Minister of Energy, Mines and Resources. In the year 1972-73, it had a budgetary appropriation of $3.6 M, of which $3.0 M was for salaries.

The Board operates under its Secretary, Robert Stead, and has a number of operational groups. The principal group of interest to this report is the Electrical Engineering Branch, chaired by Edward S. (Ed) Bell. Bell was previously with the nuclear program at Ontario Hydro, participates actively in the Canadian Nuclear Association, and has published a number of reports to do with the current economic status of nuclear power in Canada. He generally provides a good informative opinion on the state of the art and its participants.

Under its jurisdictional responsibility in the electrical field, the Board heard an application by the New Brunswick Electric Power Commission to export power to the Maine Electric Power Company Limited, the power to be generated in the new thermal electric station at Lorneville, New Brunswick. In July of 1972, the Board issued a license for this purpose.

Uranium Canada Limited (UCAN)

On January 1, 1971, Denison Mines Limited was appointed as sales agent for the joint Canada-Denison uranium stockpile. Uranium Canada Limited (UCAN), a crown corporation, was created to act as the intermediary between the Government of Canada and Denison Mines in commercial activities relating to the purchase, storage and sale of the joint stockpile. Eldorado Nuclear had held jurisdiction until this time.

The Directors and Officers of UCAN are all government officials from the Departments of Energy, Mines and Resources, External Affairs, Finance, Industry, Trade and Commerce, and Justice.

As of 1974, UCAN is to administer the disposition of uranium from government stockpiles. UCAN will continue to maintain association with Canadian uranium producers in order to aid officials of Energy, Mines and Resources in their advisory role to the Government on the state of the uranium industry.

The Export Development Corporation (EDC)

The Export Development Corporation comes under the jurisdiction of the Department of Trade and Commerce, reporting to that Minister. The Vice-President and Chief Operating Officer is V. L. (Vince) Chapin.

EDC is the government agency that approves and funds loans to foreign countries for the purpose of purchasing goods and services from Canada. The general operating parameters are that EDC will lend up to 90% of the cash value of the total contract which the foreign country is entering into, with the provision that at least 80% of the funds to be spent are directed to Canada. EDC funds were utilized for both India and Pakistan, and EDC loan of $120.0 M has been authorized for Argentina, and EDC has approved a $250.0 M loan to the Republic of South Korea. EDC has a normal upper limit of $70.0 M for a country that has acceptable international credit; therefore most considerations in the nuclear field will exceed - and by quite a considerable amount - the country's guideline borrowing capabilities from Canada. Korea, looking to a total $700.0 M program of two 600 Mw reactors, could only borrow $250.0 M (70%) on the amount required for the initial development.

2.8 CURRENT RESEARCH PROJECTS WITHIN AECL

A generalized statement of the areas of research presently active in AECL is provided. A more detailed report is presented in the Annual Report, and consultation on any specific research project is best directed through Tom Church at CRNL.

1 Nuclear Physics

AECL currently has the highest voltage tandem accelerator in the world at CRNL. It is currently operating at 13.7 million electron volts. High energy, heavy ion beams can be employed to produce a multi-range of isotopes from neutron rich to neutron poor. The isotopes and their production and use form a significant portion of this research program.

CRNL also has one of the world's most sophisticated Magnetic Spectrometers; various momentum measurements and other effects are examined.

Fluid velocity and turbulent flow studies are engaged by splitting the light source of a laser, running one portion through the fluid, and extracting information from the variation in light intensity. This leads to examination of the fluid-heat transfer formulas that are currently in use.

2 Solid State Science

Properties of metals are studied, including corrosion of the zirconium alloys by x-ray defraction techniques. Stress corrosion cracking of zirconium alloys in various environments is studied, and information is sought pertaining to the initiation of cracks and their rate of propagation.

3 Biology

Radiation effects on cells, and the damage to the genetic structure of the cell so that it becomes cancerous, is examined. Radiation causes dislocation or removal of electrons and key molecules; therefore, a search for techniques to replace dislocated electrons is pursued. Repair of radiation damage to DNA is studied extensively in micro-organisms.

4 Environmental Studies

AECL has recently launched a five-year project to study the environmental effects of radiation on a section of mixed forest near Whiteshell. Vegetation, insect and animal habits have been closely measured and catalogued in plots of approximately one square yard. Environmental studies are to examine the balance of plants and animals that might be created.

Deuterium and tritium content of water under various evaporation and temperature controls is being studied. The results might allow for the deduction of climatic conditions during the creation of the polar ice caps from spectrographic analysis of ice cores.

5 Health Physics

Continual research is done into estimation of doses of radiation and measuring techniques to assess the effect and its magnitude.

THE NUCLEAR MARKET PLACE AND ITS CUSTOMERS

3.1 ONTARIO HYDRO

Since its creation by the Ontario Legislature in 1906, Ontario Hydro has been a major force in Ontario's growth and a colourful part of it history. Through Adam Beck, the founder and principal motivating force for twenty years, by 1928, Hydro gave Ontario residents the cheapest electrical power in the world. Hydro's goal - then and now - is to supply power at cost to the Ontario consumer.

With the completion of the St. Lawrence Power Project in 1959, the last major sources of hydraulic power in Southern Ontario had been tapped. Between 1959 and 1972, the fossil fuel generating capacity has been the predominant technique responding to the demands for increased power. With the results of Task Force Hydro, Report Number Three, the subsequent demonstrable proof - through Pickering - and the escalating fuel costs, Ontario Hydro is clearly moving into its third phase of production. By 1985, it anticipates having 13,400 Mw of nuclear electric power producing capacity, 80 % of the Canadian total, and a commitment to nuclear power that is far more demanding than was the original generating station at Niagara Falls.

The early history of Ontario Hydro through until 1971 is pictorially set out in a paper written by J. Nicol and R. Harford, March 1, 1972. This deals with the trials and tribulations of the development of Ontario Hydro.

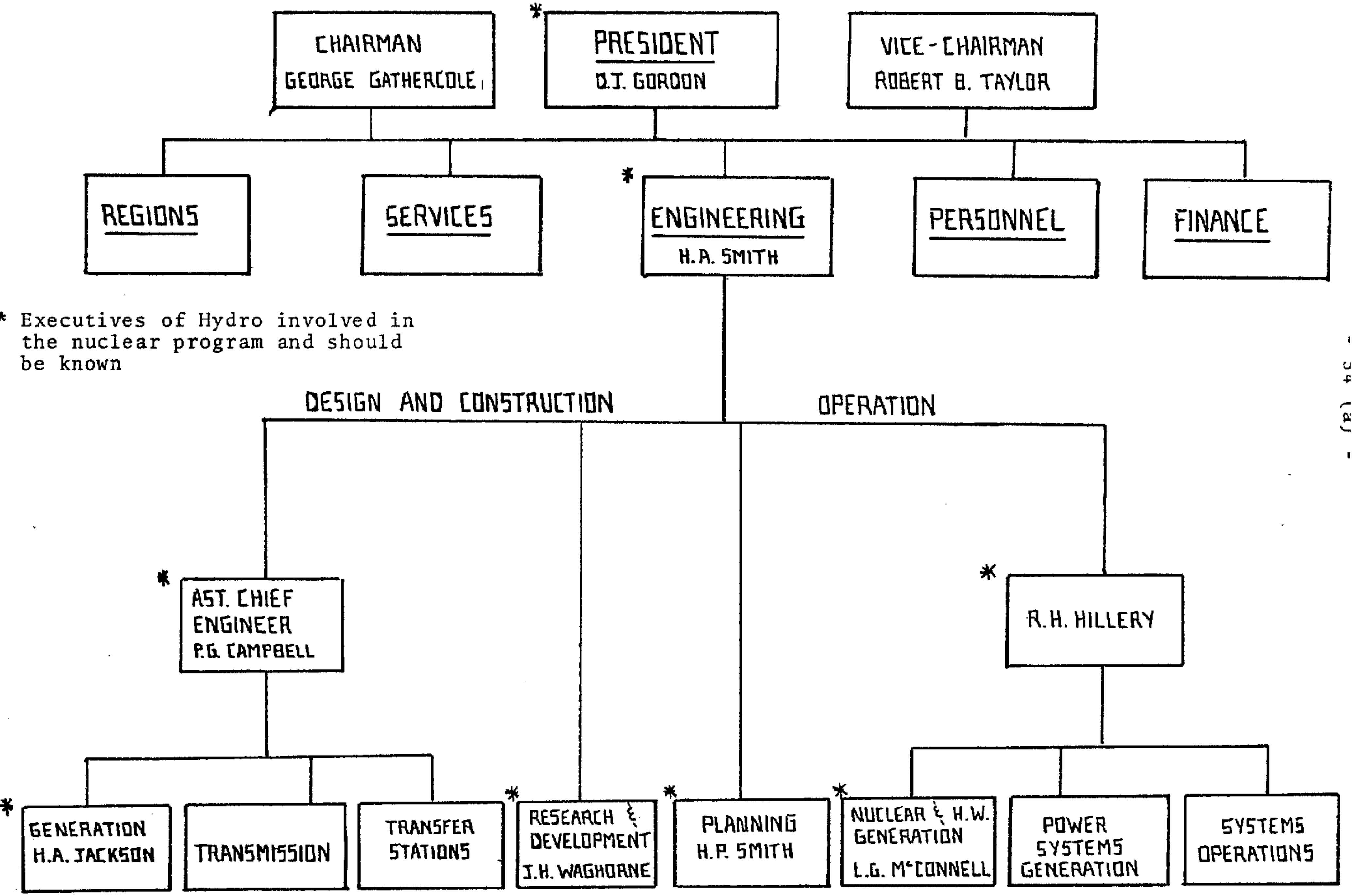
Organization

Today, Ontario Hydro is headed by G. E. (George) Gathercole as Chairman, R. B. (Robert) Taylor as Vice-Chairman, and D. J. (Doug) Gordon as President. The organization is laid out in five major divisions: Regions, Services, Engineering, Personnel and Finance. To the nuclear community, the most important division is Engineering, headed by H. A. (Harold) Smith. The Chief Engineer has always been the most auspicious and powerful appointment; Smith was hand-picked by the former Chairman, President and Chief Engineer, Dick Hearn. Smith is reputed by many to be one of the most competent and generally brilliant engineers in Canada, he is profoundly respected by his peers and by the people under his jurisdiction, and is given much credit as contributing some of the key design features of the CANDU Reactor.

There are two principals under Smith: (a) the construction of electrical generations facilities, and (b) operating these facilities. A functional organization chart is set out on the following page with the key people within Ontario Hydro who should be known to a supplier of nuclear equipment and services.

Ontario Hydro today is under fierce public scrutiny and re-examination, on a political level, as to structuring and its relationship to the Government of Ontario. This has created decision-making problems and will continue to do so for the next twelve to eighteen months. In an inflationary economy, there is a continual need for price revisions, both

ONTARIO HYDRO ORGANIZATION CHART



* Executives of Hydro involved in the nuclear program and should be known

ONTARIO HYDRO

OFFICERS AND DIRECTORS 1973 - 1974

G. E. (GEORGE) GATHERCOLE	CHAIRMAN (retires December 1974)
R. B. (ROBERT) TAYLOR	VICE-CHAIRMAN Former Vice-President and Secretary, Steel Company of Canada. Assumes Chairmanship of Ontario Hydro in December 1974
D. J. (DOUG) GORDON	PRESIDENT
W. E. RAINEY, Q.C.	SECRETARY

DIRECTORS

D. ARTHUR EVANS, M.P.P.	Simcoe Centre Parliamentary Assistant to the Minister of Energy.
J. DEAN MUNCASTER	President and Director Canadian Tire Corporation
DOUGLAS HUGILL	Income Tax Consultant, Sault St. Marie, Ontario Past President (1970) of the Ontario Municipal Electrical Association (OMEA)
PHILIP LIND	Secretary, Rogers Telecommunications Limited
JEAN PIGOTT (MRS.)	President and Chief Executive Officer, Morrison-Lamothe Foods Limited, Ottawa
ANDREW FRAME	Chairman, Burlington Public Utilities Commission Past President (1971) OMEA

J. CONRAD LAVIGNE	President, Mid-Canada Television System
ROBERT J. UFFEN (DR.)	Dean, Faculty of Applied Sciences, Queen's University, Kingston, Ontario
WILLIAM DODGE	Secretary-Treasurer, Canadian Labour Congress (retired)
ALLEN LAMBERT	Chairman and Chief Executive Officer, Toronto Dominion Bank, Toronto, Ontario

with contracts and with rates; unfortunately these have their largest effect on politically oriented bodies such as Ontario Hydro.

Organizational Personality

It is rare, indeed, to find any major organization in Canada that exhibits an almost 'cocky' self-assuredness and a deep conviction of its own abilities. Dealing in the Canadian nuclear industry, this corporate attitude or philosophy of Ontario Hydro should be well recognized. From the Chairman to the line operators, there is indeed a pride within the organization which we find unique. It has been publically reflected as autocratic and dictatorial; however, without this attitude, it is entirely probable that the Canadian nuclear program would not have exhibited a portion of the success that it has. Characteristically Canadians are like the British, only slightly less self-assured. The British program has been marred by many changes of direction forced upon them by public opinion. Several major nuclear authorities in the United States credit the recent successes of the Canadian program solely to the Canadian 'gold plated' philosophy and 'stick-to-itiveness'. These aspects have been imparted, in large measure, by the self-assurance of the Ontario Hydro team.

If dealing with Hydro, it is well to recognize that a purchasing confidence is exhibited, they are not adverse to paying a fair market price, would like to see competitive outlets, are prepared to talk factually about their long-term plans, and tend to be conservative about what will happen in the nuclear industry outside of Ontario - i.e. the rest of Canada and the rest of the world. When comparing the results of Pickering with any other reactor program in existence, Ontario Hydro certainly speaks from strength.

3.2 THE HYDRO - AECL RELATIONSHIP

Since the incorporation of AECL in 1952, Ontario Hydro and Atomic Energy of Canada have had a unique complimentary, totally co-operative relationship. Dick Hearn, the Chief Engineer at the time, was totally convinced that nuclear power would someday provide a principal mode of production of electricity within the Hydro network. He was also convinced that the Canadian technology was correct, and that we had the ability in Canada to see a program to a successful conclusion. Hearn was a prime motivator on the original Board of Directors of AECL. He subsequently committed Hydro to a number of joint venture projects, starting with the Design Task Force for proving the feasibility of power generation from the heavy water process utilized by NRX.

L. G. (Lorne) McConnell suggested that Harold Smith had been hand picked by Hearn as his successor as Chief Engineer prior to sending him to Chalk River to head up the task force to prove the viability of nuclear power. His redesign concepts, including horizontal fueling and the pressure tube technicques using zirconium alloys, played an important role in the development of the CANDU Reactor. Smith subsequently headed up the team which designed NPD, the joint venture, nuclear power demonstration project to be located at Rolphton.

Little of the inter-relationship between Ontario Hydro and AECL is formalized. In fact, McConnell expressed some small concern over the fact that, in our rapidly changing spectrum, management shifts in both organizations could be somewhat hampered by this lack of formalized association. Ontario Hydro, as an example, is known to have agreed to support any international project that AECL might be called upon to manage through training, operating assistance and provision of technical people if necessary. This understanding, initiated by Lorne Gray and Harold Smith, has no formal definitions.

It is interesting to note that key executives of both organizations compliment each other, and each suggests that without the other the program would not have survived. Formally, Ontario Hydro is the customer and AECL is the project engineer working on a fee basis. There is, of course, a contract negotiated between Smith and Gray for each reactor project. Informally, it has been a question of employing the assets of each organization to the best advantage and reimbursing AECL when required. Most of the key personnel within the nuclear programs of the two organizations are well known to each other.

This unique relationship could probably only have developed because Canada is a small country with limited technical resources. Both organizations were headed by strong individuals; both organizations had a clear mandate from their respective governments to operate with a fair degree of automony; and, neither organization was motivated by, or held to, profit considerations. Interestingly, Canada's results per dollar of research and development in the nuclear field are clearly unequalled by any other program of any other country.

3.3 THE BUYING PRACTICES OF ONTARIO HYDRO

Buying practices were outlined in an interview with J. G. (John) Matthew and J. D. (Jim) Wilson of Ontario Hydro, and represent their informal comments.

Philosophy

Ontario Hydro would like to see a healthy, competitive climate for nuclear components within their CANDU Reactor. They look on the systems as basically developed, and will be satisfied when two strong Canadian companies are capable of supplying each of the major component sections. To this end, they will direct business wherever possible to build the environment.

Hydro has been phasing out the contractor and management role of AECL from the nuclear steam plant. In Pickering 1 and 2, Power Projects did all of the buying and most of the project management; in Pickering 3 and 4, it was shared; in Bruce 1 through 4, Power Projects did a portion; and, in future nuclear plants, Ontario Hydro will do all of their purchasing directly, including tendering and evaluation.

In the reactor cores, AECL still plays a role; however, Hydro is now calling the shots. In the overall nuclear island, Ontario Hydro feels that AECL is now in the role of consultants.

Matthew commented that the nuclear activity in Canada had been strong, with many companies aggressively competing, up to the end of the Pickering purchases. After that period Ontario Hydro observed that the only on-going Canadian project was Bruce 1 through 4. Hydro sought to keep as many companies involved as possible through judiciously spreading the business for Bruce. This has resulted in a number of good companies leaving the industry in several sole-source situations. With the activity once again clearly on the up-swing, Matthew and Wilson felt it was an excellent time for companies to develop a strategem.

Reactor Component Purchasing

1 Turbine Generator Sets

These are made by two good suppliers, the business is divided between them, and Hydro is satisfied with the supply source.

2 Reactor Core Structures

These were made principally by Canadian Vickers. This single-source situation has now been rectified with the entry of Dominion Bridge into the market, and Hydro is confident that a strong competitive market will exist in the future.

3 Steam Generators

Steam generators provide a major problem as far as Ontario Hydro is concerned. Babcock and Wilcox Canada Ltd. are a sole-source supplier and have provided equipment for virtually Canadian reactor project. This is a major market and Hydro would like an alternate source of supply.

4 Primary System Pumps

Primary system pumps are now being almost totally supplied by Byron Jackson, a division of Borg Warner Canada (Ltd.) They have a technological advantage, have supplied the majority of pumps to date, and Matthews stated that, except for inflation, they would just extend the contract to continue supplying these pumps for Pickering B and Bruce B. Hydro would like to see Bingham Pumps Ltd. with a larger portion of the business; however, they will have to become technologically competitive.

5 Valves

Valves present the major purchasing problem for Ontario Hydro today. In their opinion, although there are a number of sources, we do not have a viable valve industry in Canada. Velan Engineering Ltd. in Montreal has the technology and the theoretical ability; however, they lack management expertise. Hydro does not feel they can reliably place an order with this company, and would be most interested in a major company, with management capabilities, purchasing this organization and demonstrating an ability to meet commitments. Valves, because of the importance of heavy water and the concern with any leakages, have a major impetus within the CANDU Reactor system; they are presently being bought off-shore. Hydro concedes that the valve industry has not been protected in Canada, and perhaps this accounts for the lack of in-house capability. The foundry industry, and its lack of competitiveness - with Canadian Steel Foundry being the only decent casting supplier in Canada in their opinion - was cited.

6 <u>High Carbon Steel Tubing</u>

This is a market which stills needs to be filled in Canada. High carbon steels for fittings, tubings, pipe castings, and other components necessary for the CANDU Reactor are difficult to obtain.

7 <u>Fuel Handling Systems</u>

These present a clear picture of present Hydro philosophy. For Pickering A, AECL let 350 contracts and integrated all components for the fuel handling system. For Bruce A, a sole-source contract for the fuel handling system was let to General Electric who designed and built the sub-system, sub-contracting to suppliers such as Standard Modern and Standard Tool and Dye, etc.

For Pickering B, Ontario Hydro has blocked the fuel handling system into seven or eight major packages, each in excess of $1.0 M, and they intend to go out for bids on these packages individually. AECL Power Projects will be contracted to assemble the packages for the finished product. The Hydro is principally looking to people such as Bristol Aerospace and Orenda Engines Ltd. to become involved in tendering. Hydro would like to see at least two technically capable companies bidding each of these units. If the concept is approved, they will have draft proposal specifications by July or August and will be tendering Pickering B towards the end of the year.

3.4 HYDRO QUEBEC

The Province of Quebec is endowed with significant resources in electrical generating capacity from water. By 1966, Hydro Quebec had only one small thermal plant installed as their total fossil fuel contribution to the Quebec Electric Grid. Their technical and manufacturing knowledge was totally oriented to the production of hydro-electric power.

It was natural therefore, that Hydro Quebec, when considering generation of nuclear power, would seek out engineering and design consultants for both the nuclear portion and for the steam turbine portion of the power plant. The firm that was selected was Canatom Ltd., who became the prime contractor on Gentilly 1, and are to be the contractor for the additional portion of the reactor in Gentilly 2.

Canatom Ltd. have now developed a design and engineering expertise that is competitive in the international industry, and hence have become engineers for the Argentinian project. They will also share the engineering responsibilities in projects such as Korea and other turn-key reactor programs bid by AECL.

Quebec Philosophy

Alex Taylor, President of Canatom, commented on Hydro Quebec and their relationship to AECL. He agreed that from a technical and working sense, Canatom as an organization was probably closer to AECL then was Hydro Quebec.

Yvon DeGuise is the Commissionaire for Hydro Quebec, responsible for nuclear activities. He is on the Board of Directors of AECL, and constitutes their major working inter-relationship.

Lionel Cahill is the equivalent - or slightly below - of the chief engineer position held by Harold Smith, and he is the principal line negotiating management on behalf of Hydro Quebec.

Taylor commented that because of the provincial-federal relationship in Quebec, one that is totally different to that of Ontario, the nature of the relationship between Hydro Quebec and AECL would similarly be quite different. Hydro Quebec oversees all of its own purchasing, and would be enthusiastic about any manufacturer, based in the province, who might prove capable of meeting their needs.

The principal purchasing agent for the company is Yvon Hardy. Because of Hydro Quebec's recent entry into the nuclear field, it will probably not constitute a major portion of Canadian nuclear capacity for another ten to fifteen years. However, by the end of the century, it is projected at 32%; the last five years of the century the installations are projected to equal or exceed those of Ontario Hydro. As such, present interest would be well co-ordinated through Canatom and Power Projects.

3.5 NEW BRUNSWICK AND OTHER CANADIAN UTILITIES

The first reactor project outside of Ontario and Quebec is in the final stages of approval for New Brunswick. That project was principally justified through a license to export power to the State of Maine.

Canadian utilities outside of Ontario and Quebec are only now taking a serious interest in the potential economies of nuclear power. The Federal Government, through its recent conference on energy, has clearly stated that it is committed to the CANDU philosophy; to reinforce this, Macdonald has offered up to 50% Federal financing for any province planning to develop nuclear generating facilities, provided that they adhere to the Canadian CANDU program.

Russell's projection for nuclear power calls for 28,800 Mw to be committed in the Western and Atlantic provinces prior to the turn of the century. This represents an expenditure level in excess of $12.0 billion. However, it would appear that most of the initial purchases will be strongly dictated by the experience of Ontario Hydro and the advice of AECL and Canatom. As such, with the exception of New Brunswick Hydro, contact with other Canadian utilities would not appear necessary at this time.

3.6 THE INTERNATIONAL MARKET - WHO TO SELL TO? WHAT IS BEING SOLD?

For industry to examine the future potential international market from sales of Canadian reactor technology, it is necessary first to closely examine what is being sold, how AECL is selling it, and what are the motivational factors behind these sales. These factors are likely to influence the success insofar as domestic suppliers are concerned.

A power utility in a country not possessing nuclear technology is faced with a number of marketing faces. The principal competitors are Westinghouse, General Electric, Siemans, and Canada (AECL). The first three are selling a specific product; they intend to manufacture a good number of the components and they will directly acquire significant economic benefit. The traditional suppliers have had twenty to thirty years supplying electrical equipment. They are financially powerful, have a well developed international marketing organization, and have a profit motivation.

A further aspect to be clearly recognized is that very often it is necessary to spend what may be termed 'market development' money with specific people or groups, in order to assure the sale. If a company is marketing goods, they merely increase the unit cost of these goods, capitalizing the project at a premium rate.

AECL is principally selling a philosophy. Their prime motivation is not profit, but rather to develop an international acceptance of their technology in order to enhance the domestic program for the development of a CANDU reactor technology. This enhancement occurs in two specific ways:

1 A short-term market for Canadian manufactured components is created which improves the gross sales of the domestic producers. This strengthens these companies so as to better meet the needs of the domestic program.

2 If Canada is the only country using a specific technology, then a non-technical person might assume that we are wrong. Canadian utilities will be constantly exposed to General Electric and Westinghouse marketing propaganda which might look both interesting and attractive to politicians - especially if American financing is available. It is difficult to absolutely prove the economic benefit of the CANDU technology, and therefore a final reactor decision could be made on an emotional and political basis against CANDU. Such a decision could subvert the domestic program. Another technically developed country using CANDU technology would prove politically helpful.

Who to Sell to?

There are two distinct classes of customers interested in our technology, and there are significant benefits and liabilities to consumating an agreement with each of these. It is important to examine the two, because the motivation of AECL might easily lead in a different direction then the motivation of an industry sale. The two classifications of buyers are as follows:

1 Industrially Developed Countries

An industrially developed country is one where both the technological and manufacturing capability exist to produce their own reactor program. Countries such as the United States, Great Britain, Germany and Japan have a depth of nuclear experience, and a spectrum of companies capable of producing all of the nuclear components.

A sale of our technology to one of these countries initially would involve an engineering exchange agreement. The construction of a $350.0 to $400.0 M reactor might result in a $25.0 M contract for engineering technology. A significant portion of this would be to provide the knowledge to the country or its agent company, and to the country's industries to allow them to construct the equipment. The initial sale might also generate a market for $25.0 to $50.0 M worth of Canadian equipment. However such sales would not be contractually specified, but would result when the purchasing utility looked for local manufacturers and found that the component could be purchased competitively from Canadian suppliers. Fueling machines and other such technological components would also probably be sold, especially if the reactor was to be constructed on a critical time cycle. It is unlikely however that these markets could be protected for any significant period, especially if the heavy water program is actively developed in the host country.

If countries such as Great Britain or Japan acquired the CANDU technology and aggressively pursued a CANDU program, a secondary reaction would be the result. The domestic industry in the host country - which might be significantly larger in ten years than the Canadian market - would now start to compete with Canadian industry for component sales. Since they might be supplying a broader based market, they might be in a stronger position to cost-compete than our own Canadian industry. This, of course, represents negative thinking, but at least the potential creation of competition should be clearly borne in mind, possibly affecting the Canadian industries' ability to acquire a strong profitability on components at some future period.

AECL's motivation, if a CANDU program is developed in Britain or Japan, is that a nuclear community in these countries will be philosophically in tune with our development, thus supporting the validity of the decision. For AECL, a sale to one of these countries has a strong emotional benefit, generates an immediate engineering contract for AECL, and provides them with long-range scientific feed-back; in other words, this is an optimum sale in their framework. The sale also will necessitate very little financing by the Canadian Government, and hence is legally and technically more to their liking. There is no performance burden and it provides them with domestic political credibility.

2 Underdeveloped Countries

An underdeveloped country would be classified as a country not capable of independently developing a nuclear technology. Underdeveloped countries are often characterized as lacking sufficient financial resources to finance the type of nuclear program that has been developed in Canada. To date Canada has accumulated a $2.0 billion gross expenditure in the nuclear industry, and this certainly represents an efficient use of funds insofar as nuclear development is concerned.

A sale to an underdeveloped country - such as the recent sale to Argentina or the anticipated sale to Korea - has a totally different spectrum of benefits and liabilities:

A AECL becomes the contractor and endeavours to provide a turn-key operation. They, in turn sub-contract to Canadian industry for the majority of the components and the developmental expertise. They also expect the domestic suppliers to make whatever negotiations are necessary for licensing in the foreign country, and perhaps present potential for them to create branch plants. AECL undertakes a significant financial obligation under time constraints and in a country in which they might not have control over some aspects. AECL's contract management in this regard to date has been most exemplary.

B Canada is usually called upon to become the banker. Underdeveloped countries are characterized by their lack of development capital, and any acquisition in excess of $100.0 M often hinges upon financing arranged by the seller. In the sale to Korea, the Government of Canada has agreed to bank to a total of $250.0 M, all of which will be spent in Canada. If Korea requires a second reactor, it will also require equivalent banking, generating a similar level of expenditure within Canada.

C There is a small degree of technological satisfaction. The purchasing country is usually buying based on a financial agreement and a dependency. They are buying an ability to produce, as opposed to a philosophy. Because they are looking for a turn-key operation, the performance of Pickering is a powerful sales vehicle. The host country will have little capability to modify or improve the performance of the products sold.

The political ramifications in Canada are not as beneficial. If capital constraints in the long term become overiding, then significant financing to a country that might prove incapable of repaying could prove to be a political liability.

In conclusion, the facts as presented would indicate that the sale of CANDU philosophy to a developed country is strongly beneficial, politically and technologically, but has minimal financial benefit to the industry spectrum. On the other hand, the sale of a CANDU Reactor to an underdeveloped country, while it has a potential political liability and very little technological benefit, offers extremely significant benefit to the nuclear industry. A potential supplier in this industry should therefore be critical of the total basis under which we are attempting to develop Canada's proven technology in the international framework.

An Alternative Solution

Both Lorne McConnell and John Foster suggested an interesting alternative solution. Canada should go to a number of United States utilities and offer to sell them power. The offer would include the construction of a nuclear power plant in Canada, under a licensed form of agreement. They would provide a portion of the financing and the Canadian Government would provide another portion. They would own and purchase the power, and it would be integral to their network. In this manner, the benefits would totally accrue to Canadian industry. AECL would be in an optimum position to produce - i.e. producing within the confines of the Canadian territory and in a framework that they totally understand - the program would not entirely be financed by Canadian capital, and hence would be more attractive then purely producing a domestic reactor, and the total technology would stay at home.. There are some obvious political concerns; however, it is interesting that both at Ontario Hydro and at AECL, senior executives would find this a most attractive and readily acceptable solution. It is possible that under the terms of the Atomic Energy Control Act the Canadian Government could create a new crown corporation whose sole purpose it was to develop this form of joint venture reactor creation program, within Canada, for cross-licensed sale to the United States.

Technologically this would be equivalent to the Americans having bought Canadian technology; in other words, some of the leading utility companies would be committed to a heavy water program without having to fight the USAEC control regulations. But, on the international market place, it would clearly be a victory for the CANDU concept.

3.7 TAIWAN, INDIA AND PAKISTAN

Prior to 1972, Canada had made international agreements to develop heavy water, natural uranium nuclear reactors in three underdeveloped countries. Today there exists practically no technological benefit to Canada from these developments, there is almost no liaison with the nuclear community trained and developed by Canada for these countries, and the likelihood of future expansion or development - from either an engineering or a manufacturing base - is small. These three customers bear examination.

Rajasthan

In 1966, in an agreement between the Canadian and Indian Governments, Canada agreed to provide loans totalling $83.0 M from the Export Development Corporation to allow the Indian Department of Atomic Energy at Rana Pratap Segar, in Rajasthan State, to build two 200 Mw CANDU nuclear reactors. Montreal Engineering Company and Montreal Engineering Eastern Limited were to be the engineering consultants for the conventional part, while AECL was to design the nuclear portion.

In addition to capital commitment, through the Canadian International Agency funding 110 Indian personnel were trained in power plant design and industrial techniques, as well as in operations.

Construction suffered from a number of set-backs, with the first unit becoming operation in 1972. The DAE is constructing a third 200 Mw CANDU unit near Madras, and, while the concept of this is Canadian, the content is almost entirely Indian.

In 1972 India refused to participate in the Nuclear Non-Proliferation Agreement. This immediately caused an idealogical split between the Canadian nuclear community and that of India. As a result of this stance, some fifteen months ago AECL wrote specific letters to the Atomic Energy Department of India; being unsatisfied with the replies received, they effectively terminated all scientific exchange and co-operation with India early in 1973. In the last twelve months there has been nominal exchange, and this only on a diplomatic basis.

Pakistan

In 1966, Canadian General Electric received a contract to develop a turn-key nuclear power plant with production capability of 125 Mw, at Paradise Point, fifteen miles from Karachi on the Arabian Sea. The project was built for the Pakistan Atomic Energy Commission, and was scheduled for completion in 1971. CGE called upon assistance from Ontario Hydro and AECL. The plant was of the vertical fueling variety, not utilizing the concepts as developed for the Douglas Point Reactor.

Kanupp is operating successfully, and there is little engineering assistance or scientific exchange still being provided from or with Canada. CGE maintains a technical representative in Pakistan; contracturally the agreement is complete. Of the three international customers, Pakistan is the only one we recognize, and this unit is not an AECL designed or engineered project. The Kanupp project, under AECL's agreement to take over CGE's activities, remained under CGE's control.

Taiwan

AECL's first complete year of nuclear power marketing was highlighted by the signing of a contract with the Republic of China for a research reactor to be built in Taiwan. The value of the Canadian content of the $35.0 M project was approximately $28.0 M.

The reactor was modelled directly after NRX, engineered and installed on a turn-key basis by Canatom. There was significant training and scientific interchange between Taiwan and Canada.

Taiwan now represents a rather embarrassing problem for AECL: the Island is branded a 'non country' and Canada technically cannot have dealings with the Nationalist Chinese. Poeple exchange is not possible; in discussion with senior AECL personnel, it appears that they seemed forced to concede that this particular customer does not exist. It was a fortunate customer for Canada and Canadian industry as the Island purchased their Canadian technology in cash, and it was an excellent working arrangement. The reactor is functional at this time.

Alex Taylor of Canatom commented that in 1973 Taiwan wanted to proceed with a 2,000 Mw CANDU Reactor program. They were prepared to pay cash for the equipment, but the political problems have shelved this program for three to five years.

3.8 NEW CUSTOMERS

Since 1966 Canada has had little success in marketing the CANDU concpet on an international basis. Proposals were made to Finland, Mexico, Rumania, Argentina and South Africa. The sales, however, when made - Finland is an example - were frustrating examples of political closings. The first major commitment was Argentina; a commitment without a contract has been received from Korea. These sales and their benefits to Canada are worth examining.

Argentina

In Argentina they have an organization not unlike AECL which is licensed to produce nuclear energy and nuclear power. They then sell this power to the local electric company. Siemans was successful in selling the first nuclear power plant (we bid it and lost), a light water reactor which was to be a turn-key operation with little technological interchange.

The Argentinians were dissatisfied with the results and also with the performance of Siemans. Their present acquisition is a 600 Mw CANDU Heavy Water Reactor, which they contracted for under two separate agreements. AECL was awarded a contract to provide the nuclear power plant. Canada financed $120.0 M to allow sufficient capital to buy the Canadian content; this is through the Export Development Corporation. CNEA (Argentinian Nuclear) is requesting a turn-key operation and is providing local, peso financing for the on-site construction and development. Canada has provided a buyer's credit. The Italian organization, Canada's partner in the Argentian joint venture, is financed through Italy on a seller's credit - that is, monies are provided to the Italian companies, and they, in turn, negotiate lease terms with the Argentinians.

In addition to $120.0 M EDC financing, Argentina also received $10.0 M in direct bank loans, allowing them to put up the mandatory EDC 10% cash contribution.

Korea

Our Korean negotiations are handled by Mr. Eisenberg, a Korean based agent. The Korean utility company wishes to acquire two 600 Mw CANDU Reactors, having already purchased a light water reactor from Westinghouse with marginal success. The first CANDU Reactor is a $350.0 M project, of which they have acquired $250.0 M EDC financing from Canada. If Howden Parsons receives the Turbine Generator Sets order, Britain will finance the balance. AECL will be the prime contractor on a turn-key reactor project if financing is finalized. Ontario Hydro will provide project management assistance, and Canatom will have a contract for non-nuclear engineering and project management because of an appeal by them to Cabinet to extend financing beyond $200.0 M.

The Koreans will continue to build reactors if financing can be attained. To sell to this market, Canada faces the idealogical question of whether our financial resources should be put to work in Korea, or would be better put to work building these reactors for provinces within Canada; alternatively, can Canada find an outside banker - such as the World Bank - for the Koreans.

3.9 THE FUTURE MARKET PLACE

In an interview with Gordon Leaist, he suggested that their organization was looking to the following projects:

1 Pakistan would be agreeable to building a 600 Mw Canadian CANDU Reactor immediately, provided financing can be attained.

2 Rumania will be looking for a nuclear power reactor plus a technical exchange agreement in the next one to two years. Canada appears to be competitive and are still highly regarded based on the previous work done.

3 Iran is one of the most aggressive of the Middle East countries, and the only country that is technologically advanced to the extent that it has a considerable consumption of electric power. Iran believes this power should be nuclear, saving their fossil fuel reserves for more effective use. They would also be in a position to purchase a turn-key reactor for cash, and would prove to be a very attractive customer for Canada.

4 The Mexicans would look to do the majority of the work within Mexico. The last time they tendered, the bid precluded heavy water technology. Leaist feels that for the next project Canada should be in a stronger marketing position.

5 Israel should be in the market to purchase a nuclear reactor within two years. They would need Canadian financing; however, they would constitute a high credit nation.

Leaist also mentioned that Egypt would probably request a reactor; however, it will be sold on political terms, and most likely by the United States.

Japan - Selling to a High Technology Nation

Leaist reviewed our technical exchange agreement with the Japanese, and our efforts to try and persuade them to utilize the Canadian heavy water technology. It would take at least $20.0 M to market our system in Japan; this would entail the maintenance of full-time offices and the set-up of joint programmes to examine the aspects of the heavy water reactor.

If the Japanese made the decision to launch a heavy water program, they would, on the initial 600 Mw, $350.0 M unit, probably contract for $25.0 M of engineering and $50.0 M (plus or minus) of component equipment, all purchased from Canada. After the first reactor, it might prove difficult for Canadian industry to maintain a hold on additional reactors in the country; however, for an aggressive developing company, the Japanese will enter joint venture agreements. Consolidated Computer, making data preparation units, have Japan as a major market in a field where the Japanese have technological capabilities.

The Japanese implementation of CANDU would provide technological exchange agreements which would eventually provide positive feedback to the Canadian program. The Japanese would not be looking for Canadian financing for this acquisition.

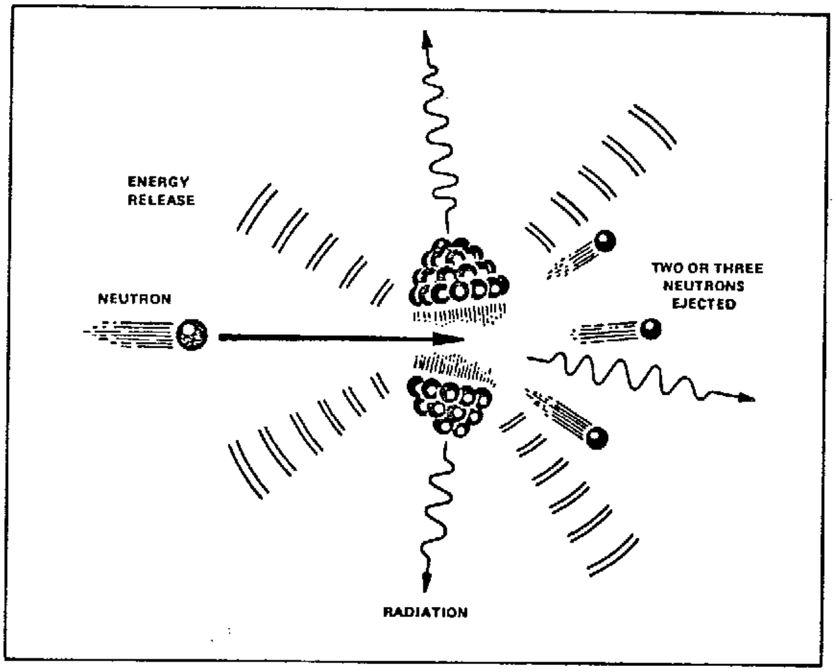
Having sold our technology and created manufacturing capabilities, a sale to Korea in ten years would probably face its major competition from Japan.

It would appear that Canada can probably build as many international reactors as it wishes to finance. The real challenge is to fund turn-key sales on a non-credit basis.

REACTORS - CANDU AND HEAVY WATER

4.1 POWER REACTORS

The entire concept of nuclear energy rests on one single principle - splitting of the U_{235} atom. When this atom collides with a neutron it becomes so unstable that it immediately breaks into two rapidly moving fragments, of more or less equal mass, plus two or three neutrons (a process known as 'fission'). These fission products are the results of true alchemy. However, of more importance, is that the process results in the production of more neutrons and, when stopped by an adjacent material, the release of large amounts of heat energy.



Normally the neutrons travel at such a high speed that the chance of them striking the nucleus of a uranium atom, thereby releasing more neutrons and fragments, is very small.

The secret then is to slow the speed of the neutrons - a process known as moderating. The substance used to effect this decrease in speed is known as a 'moderator'. Some of the common moderating materials include light water, graphite (carbon), and heavy water. Their overall performance can be stated numerically through their 'moderating ratio'. Light water has a ratio of 62; graphite of 170; and heavy water of 2,000. In Canada we take advantage of the exceptionally high moderating ratio of heavy water. The United Kingdom has followed the graphite moderator; the U.S.A. and the U.S.S.R. favour light water. In the moderator, the neutrons given off by splitting the nucleus of the uranium atom encounter the nuclei of atoms in the moderator and are slowed down. These slower moving neutrons are then more likely to strike nuclei of other uranium atoms; the result is a chain reaction.

The heat energy produced is transferred to a steam generator through a coolant which is pumped over and around the hot uranium fuel.

The fission process is controlled through the amount of uranium used, or by removing the moderator, or by ejecting a substance that will absorb neutrons and reduce the number of fissions taking place. In actual practice, combinations of these methods are used.

The three main moderators in use define the three major classes of power reactors: heavy water moderated reactors (HWR), light water moderated reactors (LWR), and graphite moderated reactors (GTR). The major coolants in commercial use which further subdivide this classification are:

pressurized heavy water (PHW), pressurized light water (PWR), and boiling light water (BLW). These reactors are fueled with either 'natural' or 'enriched' uranium.

Reactors using heavy water or graphite as a moderator can be fueled with natural uranium. Reactors with other moderators require a fuel with a higher concentration of a naturally fissionable derivative of uranium.

To complete the story, it should be noted that other coolants and fuels are under development. In Canada we are experimenting with an organic cooled reactor (OCR). This will use natural uranium as a fuel, heavy water as the moderator, but the coolant will be a light oil (CANDU-OCR).

Three reactors use gases as coolants. These include Magnox and the advanced gas cooled reactor (AGR) which use carbon dioxide, and the high temperature gas reactor (HTGR) which uses helium. The Magnox Reactor is fueled with natural uranium; AGR with enriched uranium; and the HTGR with enriched uranium-thorium.

The fast breeder family of reactors which are described later use liquid sodium as a coolant with either plutonium dioxide or uranium dioxide as a fuel (LMFBR - Liquid Metal Fast Breeder Reactor).

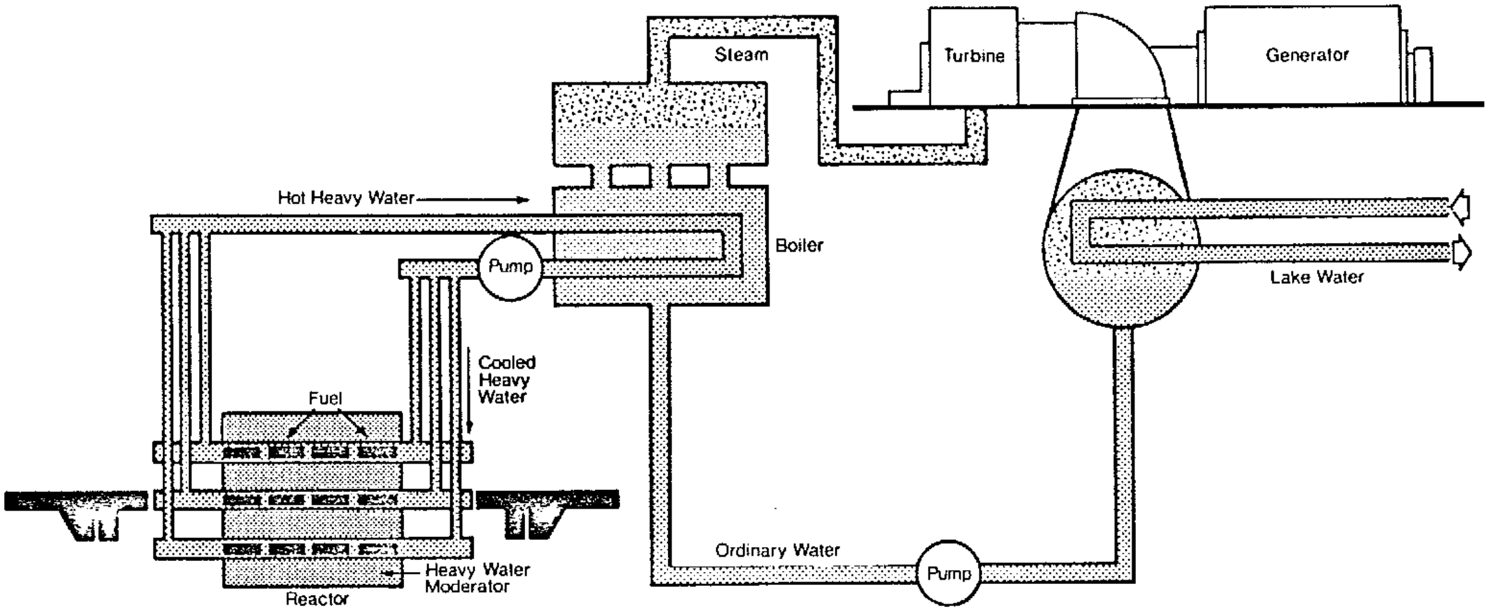
The CANDU-PHW, Magnox, AGR, HTGR, BWR, and PWR Reactors have all been actively promoted in an attempt to achieve a share and economic advantage in the rapidly expanding world markets for nuclear power plants. The Magnox Reactors and the AGR were designed in the United Kingdom. Because of corrosion problems caused by the reaction of carbon dioxide with mild steel in a radioactive environment, all Magnox Reactors have been derated. Five AGR reactors are under construction, but again, corrosion problems have beset the program. The boiling water reactors (BWR) are designed by General Electric in the United States; pressurized water reactors by Westinghouse; and the high temperature gas reactors (HTGR) by Gulf General Atomic.

In France, the gas-cooled graphite moderator reactor was the main line of development, but this phase of the program seems to have been terminated in favour of light water reactors of American design. However, because of possible problems in the delay of breeder reactors and potential restrictions on the supply of enriched fuel, the French are tracking the progress of the heavy water reactors as an alternative.

It would appear that CANDU-PHW in its present form will carry the Canadian program into the 1980's. The development on alternative fuels and alternative coolants will continue with the possibility that the CANDU-OCR design may become operational in the near future.

THE CANDU PRESSURIZED HEAVY WATER REACTOR

FLOW DIAGRAM



CANDU Flow Diagram

NUCLEAR ISLAND — NON-NUCLEAR PORTION

In 1974 dollars a 600 Mw CANDU (PHW) Reactor will cost $350.0 M. The expenditure allocation is as follows:

Reactors, Boilers and Auxilliary Equipment	46 M
Turbines and Auxilliary Equipment	31 M
Electrical Power System	15 M
Instrumentation	13 M
Heavy Water	56 M
Building, Land and Site developments	42 M
Engineering, Design, Test & Development	34 M
Operational and Maintenance Costs	25 M
Cost of Money, Financing (Pre-Operational)	46 M
Services and Miscellaneous Costs (Local)	42 M
	350 M

*Task Force Hydro Percent Cost Allocations

4.2 THE CANADIAN REACTOR MARKET

Present and Future Prospects for the CANDU Reactor

The CANDU Reactor is a Canadian development which has been designed to meet the special circumstances of this country. In particular, it can be 'factory-made' and it is predicated maximizing neutron economy (i.e. it burns natural uranium and has a reasonably high burn-up rate). Although its capital cost is somewhat higher than the light water reactors (PWR and BWR), developed in the United States, it has the advantage of extracting almost twice as much energy from uranium as any of the competing systems. This latter factor becomes increasingly important as the price of uranium escalates.

Notable features about the first large-scale CANDU power station (Pickering A) are worth noting. These are:

1 About 80% of CANDU manufacture is undertaken in Canada

2 Pickering A is the world's largest nuclear power station. When Bruce A is completed in 1983, it will be the world's largest nuclear power station.

3 Each of the Pickering reactors was commissioned according to schedule and each was brought up to full power at a rate appreciably faster than competing systems; in fact, the fourth reactor was brought up to full power in twelve days.

4 With the escalating price of uranium coupled with the limited uranium enrichment facilities (needed by all light water reactors) there seems little likelihood

of Canada abandoning the CANDU concept and a very strong likelihood that some foreign countries will adopt the system.

5 The capacity factors for each of the four Pickering A reactors have remained consistently high. The performance of the CANDU Reactors is clearly very impressive. The gross capacity factors for a range of nuclear power stations presently in operation are shown as follows:

Gross Capacity Factors of Some Major Nuclear Power Reactors (1973)

Reactor		Gross Capacity Factor
Pickering 1	(PHW)	92%
Pickering 4	(PHW)	91%
Pickering 3	(PHW)	85%
R. E. Ginna	(PWR)	83%
Quad Cities 2	(BLW)	76%
Pilgrim 1	(BLW)	73%
Dresden 2	(BLW)	73%
Quad Cities 1	(BLW)	71%
Stade	(PWR)	71%
Pickering 2	(PHW)	70%
Millstone 1	(BLW)	32%
Turkey Point 4	(PWR)	29%

Source: Financial Times (London), May 14, 1974

Notes:

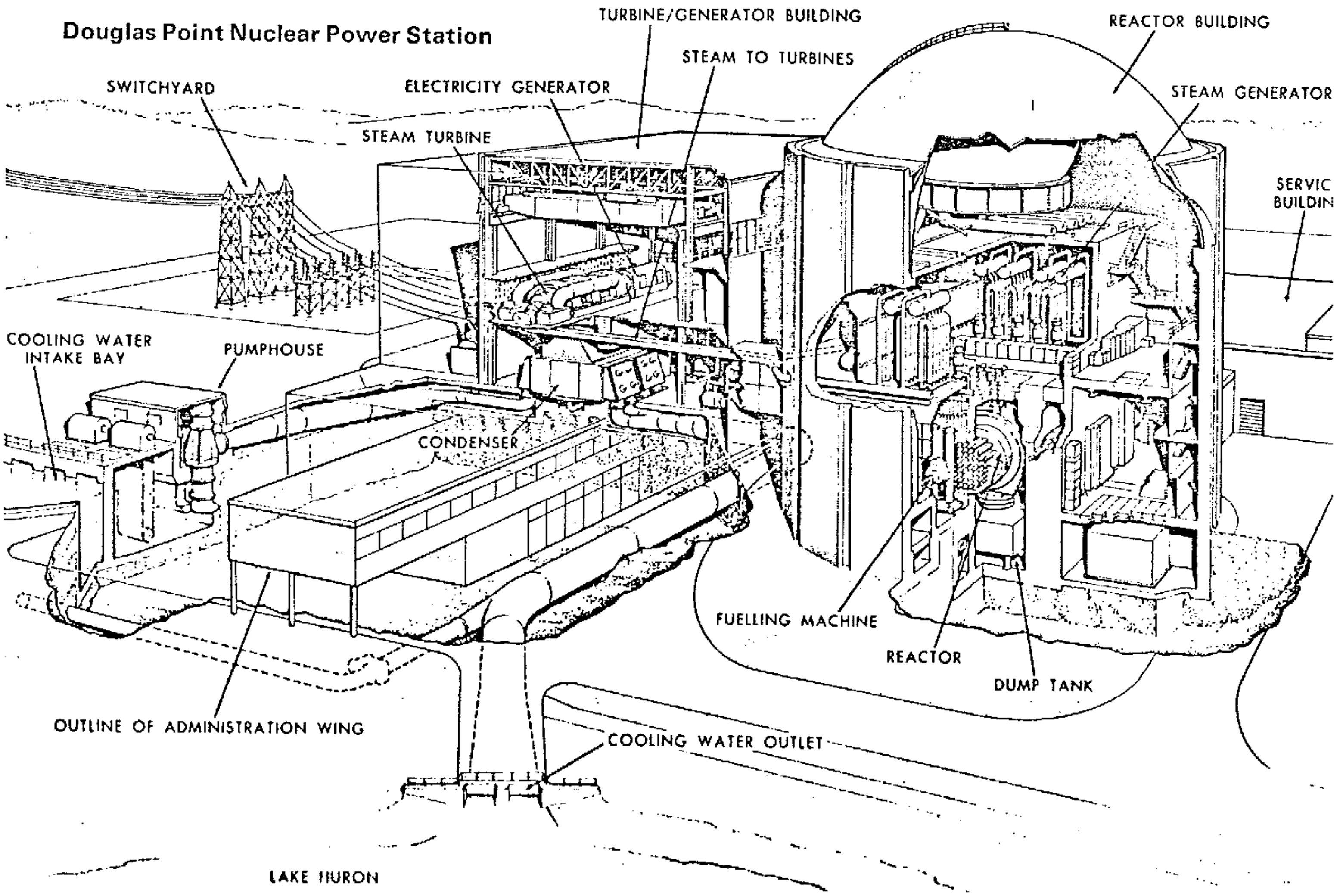
(i) A total of 32 Reactors are listed ranging in gross capacity factor from 29% to 92%

(ii) The comparatively poor performance of Pickering 2 was in part due to the failure of the turbo-generator

(iii) The Gross Capacity Factor of a generating station is the ratio of the average power load to its rated capacity, expressed as a percentage. In a nuclear plant the capacity factor covers the performance, not only of the conventional portions of the station including the turbines and generators, but also the nuclear steam supply system

(iv) The availability factor of the nuclear steam steam supply system alone would be more useful in comparing reactor types. However, capacity factor does include availability and is probably more meaningful from the standpoint of comparative overall system performance since the fact that the station generates electricity is more significant that the fact that the reactor itself is in operation.

The names and locations of present and potential CANDU power stations are listed on Page 90. Note that the total electrical power of CANDU Reactors amounts, by 1984, to 16,763 Mw. This capacity, available a decade hence, is more than the total existant generating capacity of Ontario Hydro.



The CANDU Reactor

Summary of Present and Potential Users 1967 - 1984

Name	Location	Type	Mw	Date of First Power
Douglas Point	Ontario	PHW	208	1967
Pickering A	Ontario	PHW	514 x 4	1971-73
Gentilly I	Quebec	BLW	250	1971
Kanupp	Pakistan	PHW	125	1971
Rapp 1	India	PHW	203	1972
Rapp 2	India	PHW	203	1974
Bruce A	Ontario	PHW	745 x 4	1975-78
Gentilly 2	Quebec	BLW	600	1979
Rio Tercero	Argentina	PHW	600	1979
Pickering B	Ontario	PHW	514 x 4	1980-82
Bruce B	Ontario	PHW	745 x 4	1981-83
Darlington	Ontario	PHW	745 x 4	1982-84
Not Known	N. Brunswick	PHW	600	?
Not Known	Korea	PHW	600	1980

Source: Financial Times (London), May 14, 1974

This is the environment within which CANDU competes. Pickering, with 2,000 Mw produced from four identical units, is, at present, the largest fully-operational nuclear electric generating station in the world.

Studies by Ontario Hydro indicate that Pickering is fully competitive, in terms of both cost and reliability, with fossil-fired plants of similar size and vintage in the province. The average net capacity factor, to October 31, 1973, for the four units of Pickering operating over 56 unit months was 79.5%. These figures include all lost production, whatever the nature, except for the four-month strike period. In terms of performance, three of the four units at Pickering lead the world.

Based largely on this outstanding performance, Ontario Hydro announced in June of 1973 an additional 8,000 Mw of CANDU nuclear capacity to be placed in service by 1984. This will consist of an additional 2,000 Mw at Pickering (Pickering B), 3,000 Mw at Bruce (Bruce B), and a 3,000 Mw at a new location, Bowmanville, to be known as the Darlington Station. Preliminary engineering on these units has already commenced. In addition, the Province of Quebec has announced plans for an additional 600 Mw unit, Gentilly 2.

Following this intensive program, Ontario Hydro's total installed nuclear capacity a decade from now will be 32,000 Mw, of which 13,000 Mw - or 41% - will be nuclear. By 1990, CANDU will supply 65 to 70% of Ontario's electrical energy.

Estimates for the nuclear generating capacity in Canada vary from 30,000 Mw to 40,000 Mw to be installed by 1990, and 100,000 Mw to 135,000 Mw by the year 2000. Most of this growth will be in Quebec and Ontario.

In the past, it had been assumed that coal and oil-fired units would provide most of the additional generation required in the Maritimes until the late 1980's and that nuclear generated power would become the dominant source during the 1990's. However, recent events have intensified the concern about the dependable supply and cost of oil. Because of this, New Brunswick is preparing to introduce nuclear units into operation beginning in 1980. Forecasts indicate that by 1990 between 1,000 Mw and 3,000 Mw of nuclear generating capacity will be installed in the Maritimes, and that this will grow to between 4,000 Mw and 8,500 Mw by 2000. Most, if not all, installations will be 600 Mw units.

Quebec still has substantial untapped hydraulic potential. Not until after 1985 will the bulk of additional generation come from nuclear units. Predictions for the nuclear capacity in Quebec range from 6,500 Mw to 7,500 Mw installed by 1990, and for 25,000 Mw to 40,000 Mw by 2000. One or two 600 Mw units may be installed before 1985, but, following that, most of the new generation will probably come from 1,200 Mw units, with 1,800 Mw units introduced into service in the 1990's.

The Ontario Hydro system will probably reach 25,000 Mw of nuclear generating capacity by 1990, and 65,000 Mw by the year 2000. It seems likely that most of the units to be installed from 1985 to the end of the century will be 1,200 Mw, with a few 750 Mw units being built earlier in the period, and a few 1,800 Mw units coming into service towards the end of the century.

Unitl 1990, Manitoba's electrical energy will be met largely through hydraulic resources. After 1990, this province could turn to thermal, and in particular nuclear units, to provide the bulk of additional generation. Manitoba has already indicated an interest in acquiring one or two 600 Mw nuclear units by 1985 to provide an orderly introduction into the construction and operation of nuclear power.

The indigenous supplies of fossil fuels in Saskatchewan and Alberta are plentiful and therefore it seems likely that the two provinces will continue to build fossil fuel units to the year 2000.

British Columbia is well endowed with both hydro and fossil fuel resources and it seems highly probably that it will rely on these for electrical generation needs at least to 1990. However, some nuclear units may be installed before then to provide power to specific localities with particular requirements, such as Vancouver Island.

In summary, predictions for nuclear power to be installed in the Western provinces range from 1,000 Mw to 5,000 Mw by 1990, and from 8,000 Mw to 20,000 Mw by 2000. Almost all installations will be 600 Mw units with a few 1,200 Mw units being installed toward the end of the century.

These projections of installed nuclear generating capacity in Canada, and the number and size of generating units, are summarized in Tables 1 and 2 on Page 94. If these forecasts are achieved, the total investment in nuclear power plants in Canada could reach $10.0 billion by 1985, $20.0 billion by 1990, and more than $60.0 billion by the end of the century. Even these figures could be exceeded if the rate of inflation proves greater than economies realized through economies of size and quantity.

TABLE 1

INSTALLATION OF NUCLEAR GENERATING CAPACITY IN CANADA (MW)

Period	Atlantic Provinces MW	Quebec MW	Ontario MW	Western Canada MW	Total for Period
to 1980	600	1,200	4,250		6,050
1981 - 85	600		9,150	1,200	10,950
1986 - 90	2,400	6,000	10,200	3,000	21,600
1991 - 95	1,800	13,800	17,400	5,400	38,400
1996 - 00	3,000	18,000	19,200	10,800	51,000
Total	8,400	39,000	60,200	20,400	128,000

TABLE 2

INSTALLATION OF NUCLEAR GENERATING UNITS IN CANADA

Period	500 MW	600 MW	750 MW	1200 MW	1800 MW
To 1980	1	3	5	---	---
1981 - 85	3	3	7	2	---
1986 - 90	---	9	4	11	---
1991 - 95	---	12	---	23	2
1996 - 00	---	15	---	23	8

4.3 CANDU AND ITS ECONOMICS

Over the past ten years numerous articles have been written attempting to compare the economics of the CANDU Reactor with those of other technologies. The international market place - and, in fact, some leading Canadian consultants - branded the CANDU concept as too capital intensive, and reached the conclusion that utilizing Canadian technology would prove too expensive for the generation of power in the long term.

Task Force Hydro reached the conclusion that the apples and the oranges are of at least equal magnitude. This was prior to Pickering. Since that time, the dramatic performance which is being demonstrated at Pickering appears to amply justify the decisions of Ontario Hydro.

Reviewing the various material available, it would appear that any direct comparison is virtually impossible. Canada, at enormous expense, is committed to a technology which is producing a highly reliable, and probably cost-competitive alternative, and that is the direction in which this country will go. Ontario Hydro has done a cost comparison between Pickering and their four, 500 Mw Lambton coal-fired station, possibly the most effective in the world. Their conclusion, in the 1973 fuel market place, was that the unit energy cost from Pickering was 6.2 mills per kilowatt, while that of Lambton was 7.0 mills per kilowatt, giving a 10% cost advantage to the nuclear power. Since that time, and over the next few years, fuel costs can expect to double. As fuel at Lambton represents 70% of the unit cost of generating electricity, whereas fuel at Pickering represents less than

15 % of the costs, a doubling of the cost of energy source would add five mills to Lambton but less than one mill to Pickering. Clearly, there is no longer a debate on the cost economics, especially considering environmental aspects, the trans-mobility of fossil fuels, and the fact that some of them must be imported to Canada. Fossil fuel generators still will provide a very valuable compliment to the spectrum for meeting peak load requirements, but the majority of the base load will be derived from uranium.

The International Market Place

The Canadian technology should prove attractive to other countries, especially because of the use of natural uranium, allowing for a wider base of purchase and hence a more secure basis of supply. On observation, however, it would appear that a significant financial benefit to Canada will only accrue if the developing country contracts for the first reactor. Once the technology is transported, and once that country has developed a nuclear expertise, the benefits on future reactors will be less significant. Some key components will continue to be imported and some design and development expertise will continue to be solicited. The sale of reactors is not equivalent to the sale of aircraft, in that it is not something we effectively manufacture in Canada and export at a fixed price per unit; reactor selling is fundamentally design and development assistance to a foreign country, and involves some co-operative assistance from Canadian industry with nuclear expertise. Lorne McConnell's estimate was that the benefits to Canadian industry from the international marketing of

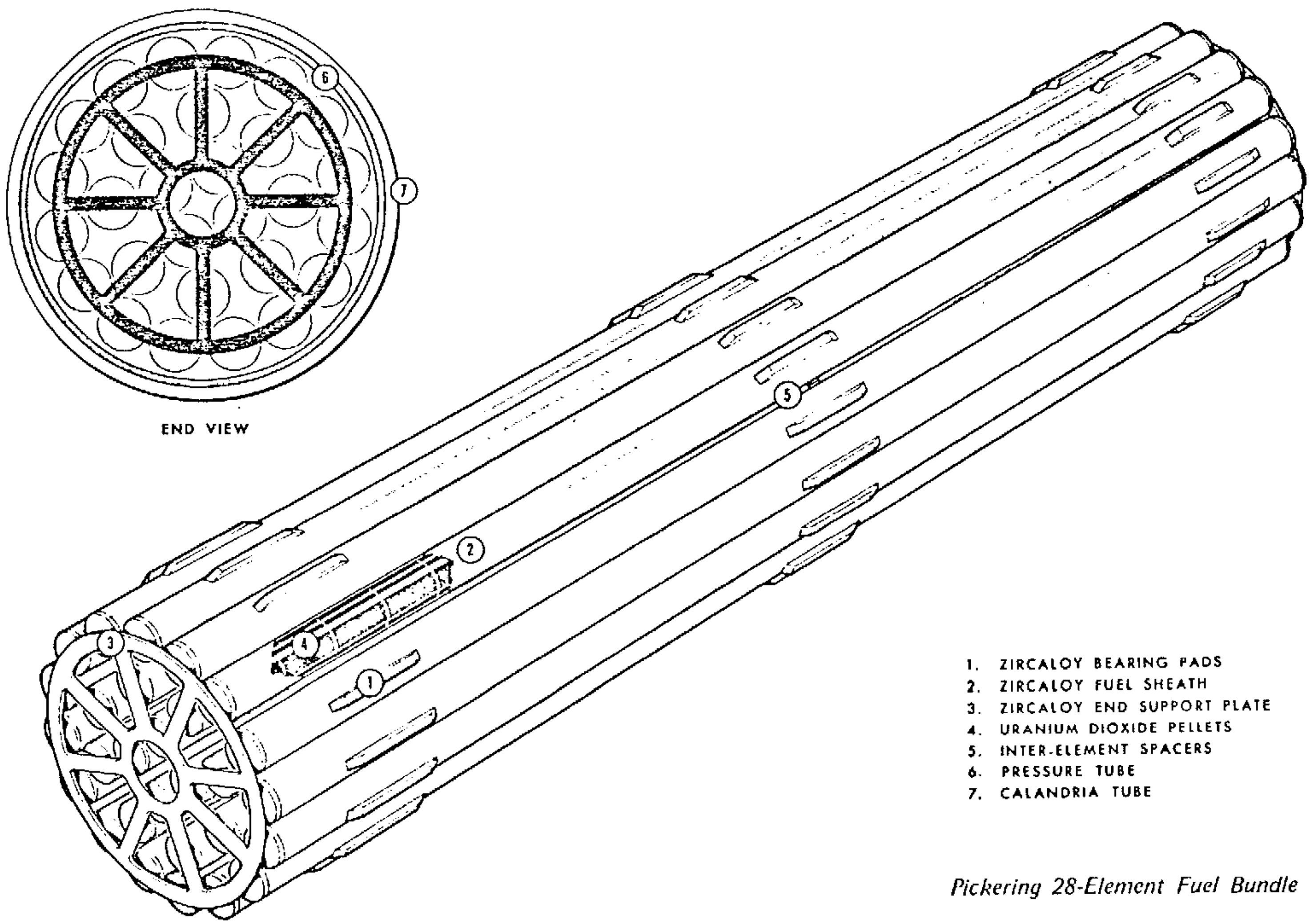
CANDU would always be less than five percent of the business they attained from the domestic program.

The international market was reviewed in depth in 3.6.

4.4 NUCLEAR FUEL - ITS AVAILABILITY AND PRODUCTION

The fuel for the CANDU Nuclear Reactor is natural uranium. The actual fissionable product within natural uranium is U_{235}, which occurs at one pound for every 140 pounds of natural uranium.

It is useful to note that a fifty pound uranium fuel bundle is equivalent to 500 tons of coal, or 100,000 gallons of fuel oil. From a fuel mobility aspect alone, uranium is a most attractive fuel source. In addition, the majority of Canada's coal for energy is imported from the United States, and the oil must be transported many miles, being diverted from other more productive uses.



Pickering 28-Element Fuel Bundle

Ownership of uranium in Canada is under provincial jurisdiction; however, based on the Atomic Energy Control Act of 1946, Section 92-10 C, the responsibility for the development and control of uranium resides with the Federal Government. It is under this jurisdiction that the Ministry of Energy, Mines and Resources has taken an increasingly active role in the uranium industry and its development for Canada.

By 1959, Canada reached the venus of its uranium producing history. International demand led by the United States was high, and, in that year, Canada produced 15,892 tons of U_3O_8, which had an export value exceeding $330.0 M, from 23 operating mines. Between 1962 and 1972, a continual buyers market existed, an over supply situation was in abundance, and Canada developed, in two stockpiles, 19 million pounds of U_3O_8, 80% of this having been produced by Denison Mines. World price had sunk to less than $5.00 per pound, and only three mines were still in production. Uranium production of 1973 totalled 4,824 tons - about 20% of the western world's production. In 1973, and continuing on into the current year, a dramatic supply/demand turnaround has occured: Uranium has reach $13.00 to $14.00 a pound, a substantial portion of Canada's stockpiles have been sold, and new mines are coming into production. A joint venture between Gulf Minerals Canada Limited and Uranerz Canada Limited, located at Rabbitt Lake in northern Saskatchewan, will be producing 2,250 tons per year by 1975. A wholly owned subsidiary of French companies will be producing in excess of 2,000 tons by 1977 near Cluff Lake in northern Saskatchewan. By the end of the decade, Canada's output could approach 16,000 tons per year, and would remain at 20% of the world's estimated annual requirements of 80,000 tons of U_3O_8.

The history of the uranium industry and its immediate projections, combined with the government legislations, has been well set out in a paper by Dr. O. J. C. Runnalls, entitled The Interface Between Government and Business in the Uranium Industry, published in 1974. Dr. Runnalls is extremely well informed and quite prepared to review, in detail, problems and likely development patterns which will occur in Canada. He is with the Department of Energy, Mines and Resources.

Task Force Hydro Report noted that 86% of Canada's proejcted production is slated for export, and this led to a recommendation that formal steps be taken through contractural arrangement, to ensure that Ontario Hydro has an assured supply of natural uranium to meet its potential requirements of its nuclear power program until at least the year 2000.

Dr. Runnalls estimates that 'considerable reserves of uranium are likely to exist in higher concentration than the three parts per million in the normal crustal abundance. At that rate, however, the energy content of a rock is ten times as high as that from good coal.'

The normal industry figure for exploration is about $1.00 per pound in Canada. We should therefore be spending $500.0 to $800.0 M between now and 1980 for uranium exploration. The current trends in taxation policy make it highly unlikely that this amount will be spent.

4.5 HEAVY WATER

By the 1960's Canada was firmly committed to the use of natural uranium as the fuel in its nuclear power program and to heavy water as a moderator. Therefore an assured supply of heavy water became as critical as an assured supply of fuel if electricity capacity was to be dedicated to the CANDU concept.

For each megawatt of nuclear capacity committed, about one ton of heavy water is required for the initial charge. This means that the expansion of heavy water production facilities must take place at the same rate as increases in the commitment to CANDU nuclear stations. For this reason, Ontario Hydro is now considering installing heavy water production capacity to match the increasing installed capacity in the province.

At the beginning of the Canadian program, the supply of heavy water was purchased from the United States on a fee basis, specifically from plants operated by the Dupont Company. The United States Atomic Energy Commission (USAEC) had been unable to interest American industry in the risk-rewards involved in the production of heavy water.

By 1960, no company in Canada had tabled a viable proposal for the production and management of a heavy water plant. Then, Deuterium of Canada Limited, backed by the Nova Scotial Government, submitted a proposal for the construction and development of a plant in Glace Bay, Nova Scotia. This company was the product of Jerome Spievak who had been a physicist with USAEC. He persisted in the development of experience in the chemical area, contracted to produce a heavy water plant at Point Tupper in Nova Scotia. CGE hired the Lummus Company of New York to design the plant, as Lummus was the only company in the world with design experience in heavy water plants.

By 1966, the supply of heavy water was in a mess; in fact, Canada's whole nuclear program appeared to be in jeopardy as a secure supply of heavy water became more remote.

To commit Unit Number Three at Pickering required that Canada borrow heavy water from several countries. Obviously strong action was required by AECL and Hydro. John Foster and Lorne McConnell were jointly responsible for the announcement in 1968 of an 800 ton per annum heavy water plant to be constructed on the same site as the Bruce Generating Station. This unit went into production in 1972 on schedule.

In 1968 and 1969, AECL once again solicited industry participation. C. H. (Church) Hantho, Vice-President of CIL, spent considerable time seeking an acceptable working relationship. CIL did not wish a straight management contract as the return on their personal resources was too low. AECL was not prepared to pay a high enough price for heavy water to give them acceptable returns on investment. Hantho felt AECL could have got participation with more research and a more equitable shared agreement.

In 1970, Polymar Corporation (now Polysar) took over negotiations from CIL and subsequently found the project too expensive for their capabilities.

By 1970, Ontario Hydro had realized the magnitude of designing, building and operating a heavy water plant. When they decided to go into the business, they recruited a team from Dupont, Union Carbide, and Imperial Oil, and now have one of the strongest chemical plant management teams in North America.

It was these developments that led to the recommendations tabled in the Task Force Hydro Report that,

> ". . . appropriate steps be taken to ensure that adequate heavy water is available in time to satisfy Ontario Hydro's planned CANDU nuclear program, and to support further commitment of CANDU reactors in Ontario and elsewhere."

Based on these recommendations, and because an 800 ton heavy water plant requires about 200 Mw of power, Ontario Hydro has planned for two heavy water plants at Bruce, and a heavy water plant at Pickering. Hydro Quebec is planning the installation of a heavy water plant at Gentilly. By 1980, Canada will be producing 90% of the world's heavy water.

Since mid-Januray, eight companies have expressed an interest in helping to finance and build four heavy water plants for Canada's nuclear market. This follows the government's appeal to private industry for more firms to become involved. Neither the government nor Ontario Hydro will release the names of the firms that have inquired about participating in the huge project. However, it is recognized that experience and resources both financial and technological, will be prime considerations in this expensive and complex game. The contracts to be let will be for the construction of four, 400 ton per year heavy water plants valued at a total of $550.0 M. The four plants are to be built on the site of the two present Bruce Heavy Water Plants near Douglas Point.

The major company involved in the project again will be Lummus Corporation (Canada), a subsidiary of Lummus Corporation of New York which itself now is owned by Combustion Engineering Incorporated of Stamford, Connecticut. Lummus (Canada) is still acknowledged to be the only firm capable of handling this huge project. It has more than 500 workers in Toronto, mostly engineers with a background in nuclear, chemical, and related technological backgrounds.

While the Ontario Government is urging private enterprise to finance the four new heavy water plants, the Federal Government recently financed construction of the $250.0 M 800 ton plant at Gentilly. Construction of this plant is to begin early in the summer of 1974 and will employ 2,000 workers. Production of heavy water is scheduled for 1978. The Minister of Energy, Mines and Resources has stated that another Ottawa financed heavy water plant will be built at an unspecified date in either Manitoba or Saskatchewan.

4.6 THE STAGE OF INNOVATION OF THE CANDU FAMILY OF REACTORS

The operating characteristics of Pickering A, especially when compared with those of competitive light water reactor systems, indicates already that a significant measure of success has been achieved. Nevertheless there is a continuing process of innovation in hand. For example, the design of Bruce A differs in some major respects from that of Pickering A - noteworthy is the fact that there are one-quarter the number of primary circuit pumps in Bruce A as in Pickering A, in spite of the fact that the former system has potentially 50% more power output. Inevitably this means that appreciably larger primary circuit pumps have been designed for Bruce - the reason for this basic change is that at the time Bruce was being designed no operating characteristics of Pickering were available and such a major innovation was considered to be desirable. In view of Pickering's success, it is not improbable that the original primary circuit pump system will be re-introduced in subsequent power stations (depending on performance of the Bruce pumps.)

There are, however, still some problem areas in which enhancements are warranted. Bill Morrison commented upon some of the most important relative to our areas of interest:

1 There will be continuing need for, and efforts to produce improved 'in-core' devices and instrumentation because with increasing levels of protection (necessitated by proliferating numbers of nuclear power stations.)

2 Associated with the proliferation of in-core devices and the associated monitoring systems is the need to improve reactor 'shut-down' performance and controlability, especially in ensuring higher reliability of performance. For instance, Bill Morrison pointed out that a previous Spar proposal to develop flexible stem devices for the shut-down reactors might still be a very important alternative approach because it is independent of the location of the shut-down system. In particular, the stem device shut-down system would be appreciably more compact than existing systems and this could be a major advantage. It was considered that more perseverance in the development of such systems might pay off.

3 In view of the complex monitoring system in the central reactor core (required to maintain a desirable neutron flux profile), the 'in-core' monitors in addition to being highly sensitive instruments are also subjected to intense environmental conditions and their design is by no means optimum at present. Apparently the basic problems are essentially of the mechanical nature, and certainly constitute a technological change. Similarly small highly sensitive geiger counters are a continuing requirement.

4 Another potentially important area where innovation is needed relates to the monitoring of individual channels to locate 'failed' fuel elements. There are a total of 390 channels per reactor, each of which contains 12, 28-element bundles of fuel. Quoting

system (developed at the Whiteshell Nuclear Laboratory) has been virtually suspended, perhaps within the next decade this effort will be renewed. The major advantages of the OCR system, as compared with the CANDU-PHW is the reduced requirement for heavy water, the fact that higher operating temperatures are feasible leading to thermodynamic efficiencies in the region of at least 38%, which compares favourably with the existing efficiency of the Pickering Station, which is in the order of 29%. Furthermore, it has been pointed out that the OCR system is easier to maintain and gives ready access due to negligible radioactivity of the coolant and the slef-disclosure of any leaks. The OCR system is very flexible relating to fuel and will 'burn' thorium, uranium and plutonium. A potential advantage of increasing importance is that the CANDU-OCR many cost substantially less per kilowatt than is the case with existing systems.

It is important to note that Dr. David J. Rose, Professor of Nuclear Engineering at M.I.T., has recently stated that:

> "If the United States were starting its reactor program today, with no large commitment already made, the Canadian ideas (i.e. the CANDU-OCR concept) would merit serious consideration . . . "

Accordingly, in spite of the fact that several key problems remain in the development of the OCR system (one of them being the inflammability of the coolant) there is obviously considerable scope and the probability of further development is high.

Although Dr. Lewis, ij his seminar, pointed out that 1,500 Mw of CANDU-OCR could not be built in much less than 15 years because a new experimental reactor would be a first requirement, the system is so attractive that he urged strongly that such a development be put in hand. Of prime importance is the fact that a 1,500 Mw reactor is smaller than a 500 Mw Pickering reactor and hence the capital cost should be lower. Dr. J. S. Foster suggested that AECL would like to joint venture an OCR program with a major international corporation who could then market the product.

The fact that thorium is an unexplored energy resource (apparently the magnitude of thorium resources may be somewhat higher than those of uranium resources) is also significant. Twenty Kw of uranium in a Pickering reactor releases as much heat as the burning of 560 tons of superior coal. In a thorium fuelled OCR, the energy yield of a 20 Kg fuel bundle would be equivalent to the burning of over 2000 tons of coal. Because of existing limitations in capital and certainly in manpower there has been a phasing out of the OCR system. However Dr. Lewis in particular is quite certain that it will be resuscitated in the not too distant future.

At a meeting held on May 24, 1974 (Harold Smith, Lorne McConnell, Bill Morrison, A. Porter), Mr. Smith stated that the time was right for a massive attack on thorium fuelled reactors (e.g. CANDU-OCR) especially the 'valubreeders' - e.g. 'use of thorium fuel for value and energy yield, and enriched uranium, as the lowest cost source of spare neutrons'. This is a highly significant comment.

In Science, Vol. 184, P. 877, May 24, 1974, there appears a strong criticism (by the Environmental Protection Agency) of the proposed LMFBR on both 'safety' and 'economic' grounds. The EPA 'points to half-a-dozen technical flaws of omissions, all of which have the effect of either inflating the projected benefits or minimizing the costs.'

4.7 ALTERNATE SCENARIOS FOR CANADIAN NUCLEAR DEVELOPMENTS

The scenarios are presented briefly because during the next two decades, the case for continuing the development and production of the CANDU series is so impressive. They are:

1 The Fast Breeder Reactor (FBR)

2 The High Temperature Gas Reactor (HTGR)

3 Combinations of 1 and 2

4 The Fusion Reactor

The Fast Breeder Reactor (Fast Reactors)

In spite of the massive financial support for the liquid metal fast breeder reactor (LMFBR) by the U. S. Government - a total of more than $2.5 billion will be available between 1975 and 1979 - there are many scientists and engineers who doubt the feasibility of the project. For instance, Dr. Lewis rejects the idea that the FBR reactors 'have potential economic merit', and he asserts that 'they may never compete'. A major difficulty appears to be that of developing materials capable of withstanding the fantastic environment which will be created in the FBR (both high temperature and high neutron flux density). On the other hand, supporters of the project assert that the potential advantages of the FBR outweigh its innate disadvantages. A major advantage being that a non-pressurized system can be more completely sealed and hence will be safer than a pressurized collant system. Moreover, the fact that the FBR will operate at appreciably higher temperatures than either CANDU or the LWR systems means that the thermodynamic efficiency is appreciably greater (it is planned to achieve about 41%). Not least of the disadvantages is the fact that liquid sodium at about 600 ^{0}C becomes intensely radioactive and constitutes a major chemical hazard if failures in circulating pumps, heat exchanges, etc. arise. In commenting on the future prospects of the FBR, Dr. Rose has stated that:

> "In the meantime (i.e. between now and A.D. 2020), nuclear power is in no danger of losing out to other fuels, and there does not need to be a crash breeder program. Economic introduction at A.D. 2000 would be a sign of technological good fortune, not of resolving an energy crisis with a time limit."

In other words, Rose does not support the FBR crash program and estimates that it will only become attractive perhaps in 50 years when the cost of uranium oxide is at least $50.00 a pound (in 1974 dollars.)

Our view is that the probability of Canada developing a FBR is extremely remote for the following reasons:

1 the highly successful CANDU Reactors, with their excellent neutron economy characteristics, will not readily be replaced by a system which may well take 25 years to develop and to satisfy essential safety requirements;

2 the capital cost of the FBR is likely to be very high - probably appreciably higher than that of an equivalent capacity CANDU;

3 the CANDU-COR, which burns thorium is itself a 'thermal breeder' and, according to Dr. Lewis, could supply much of the world's energy needs for several centuries - why, therefore develop the FBR?

High Temperature Gas Reactors (HTGR)

The HTGR is a gas cooled reactor which uses fully enriched U_{235} as fuel. Because it operates at a higher temperature than CANDU, the thermodynamic efficiency of the HTGR is expected to be as high as 40%. The major disadvantage is the fact that fully enriched fuel is a requirement and it would obviously not be to Canada's advantage to be dependent on the supply of such fuel from the United States (especially since the U.S. is a competitor in the nuclear field). Accordingly the possibility of Canada developing and manufacturing a nuclear system of the HTGR type is remote.

FBR AND HTGR

Another interesting scenario relates to the possibility of reactor systems being used in tandem in a special way. This concept is being actively pursued in West Germany. The argument goes as follows. To date nuclear power has been developed essentially for the competitive production of electricity only. Since electricity's share of the total primary energy demand is unlikely to excede 40% - 50% certainly - during the next 50 years, how can nuclear fission become the major source of primary energy? The answer is 'by reactors that provide process heat at high temperatures'. The point, of course, is that such process heat generators would avoid the comparatively low efficiencies of all thermal-electrical generating stations in use today. The German concept involves the use of the FBR to produce electricity and at the same time to produce the required U_{233} fuel for a HTGR, which in turn produces the process heat. While it ismost improbable that such a system would be considered in Canada, there may nevertheless be other alternatives predicated on the same general principles. This is a fascinating area which must be explored in depth.

Fusion Reactors

There is no evidence to date that a fusion reactor will be an economic reality at some date in the future. Because of the massive engineering problems, not least being those relating to research needed to be done on new high temperature materials, few scientists and engineers predict that the fusion reactor will be economically viable within the next fifty years. Of course, the advantages of a successful outcome are considerable, not least because the supply of fuel for such a system would be virtually infinite. But, in spite of the very considerable costs (the U. S. will spend $1.5 billion between 1975 and 1979), this option is only of academic interest in this country. Dr. O. J. C. Runnalls estimated that it would take $4.0 billion to prove the viability of fusion for power generation.

4.8 WASTE DISPOSAL

Radioactive wastes are generated in practically all areas in the nuclear fuel cycle and accumulate as either liquids, solids, or gases with varying radiation levels. Liquid radioactive wastes are generally classified as high, intermediate or low level based on the concentration of radioactivity in the specific waste streams (expressed in curies per litre or concentration relative to maximum permissible).

These classifications are of importance primarily to the plant operator and provide an approximate indication of the degree of confinement and control which must be provided for the processing or interim storage of each type of waste.

High level liquid wasts are those which, by virtue of their radionuclide concentration, half-life and biological significance, require perpetual isolation from the biospere. Intermediate level liquid wastes is a term applicable only to radioactive liquids in a processing status which must eventually be treated to produce a low level liquid waste, which can be released, and a high level waste concentrate which must be isolated. Low level liquid wastes are defined as those which, after suitable treatment, can be discharged to the biosphere without exposing people to concentrations in excess of those permitted by regulation.

The terms 'high level' and 'low level' should not be applied to solid waste in the same sense as to liquids because the concept of maximum permissible concentration of radioactive materials in the environment cannot be directly applied.

The term 'low level' is frequently applied to commerical burial sites and refers to the hazard potential of the radioactive material buried and should be interpreted as indicating little likelihood of dispersal into the environment either by water or by air.

Products such as strontium, cesium, and promethium, recovered during irradiated fuel processing operations are already finding useful commercial applications. Others such as xenon, krypton, rhodium, and palladium are being considered for recovery because of their potential use in the electrical, oil and chemical industries. Of particular interest in the by-product category is neptunium, which is used as the target material in the production of plutonium 238. It is possible that at some future date there will be a very large demand for PU_{238} for use as a power source in the space program or other areas such as the artificial heart program.

Nuclear power plants are designed on the basis that essentially all of the irradiated products created during the operation will be held captive in the fuel element. When spent fuel is removed from the reactor, it is stored temporarily under water. At the Pickering Generating Station, this temporary storage facility resembles an indoor swimming pool and its capacity is large enough to hold many years of spent fuel.

The disposal of spent fuel depends on many factors including the price of uranium, reprocessing costs, plutonium value and the extra costs of recycling plutonium. To date, analyses have indicated that it is better to sell spent fuel outside Canada than to recycle the plutonium. In fact, by 1971, over 40 tons of spent fuel from the NPD and Douglas Point reactors had been sold. Whether the spent fuel is sold or recycled, its value during the next two decades will probably lie in the range of $10.00 to $20.00/k U.

Various authorities regulate transportation of nuclear materials by air, rail and sea. All obtain technical advice from the Atomic Energy Control Board on packaging and shipping procedures for radioactive material. The AECB regulates the transport of radioactive materials by road pending the designation of an authority to regulate all aspects of the transport of dangerous commodities.

Spent reactor fuel elements, as discharged from the reactor, are far too radioactive to reprocess or ship easily and are, therefore, placed in cooling basins. The shorter-lived radioactive products are allowed to decay in the fuel while it is stored in a cooling basin at the reactor site. The high burn-up fuels from light water reactors produce as much as 15,000 watts radioactive decay heat output per element continuously at the time they are packed into shipping casts. The high heat load and the radioactivity in the spent fuel combine to make its handling and transportation very expensive due to necessary safety precautions against contamination. Heavy lead and uranium shields and stell encased caskets, ranging from 30 to 100 tons in weight are required.

The United States Atomic Energy Commission indicated in a report published in 1969 that a number of private companies in the United States are establishing reactor engineering and maintenance services to serve the growing nuclear utility industry. These services include: Assessment of plant performance, evaluation and recommendation for reactor modification, installation and testing of modification, nuclear training, maintenance, in-service inspection, quality assurance and reactor refuelling. Specifically, it was indicated that in-service inspection of pressure vessels has potential for growth. Believing that additional assurances of nuclear reactor vessel integrity were necessary, the Advisory Committee for Reactor Safeguards in October, 1966, recommended to the Atomic Energy Commission that 'extensive periodic inspection' methods be developed. Following this, requirements for in-service inspection were incorporated into a draft code issued by the American Society of Mechanical Engineers, sponsored by the American National Standards Institute, Sub-Committee 20-45.

AECL COMMERCIAL PRODUCTS

IRRADIATION AND RADIO ISOTOPES

Introduction

Radio activity was recognized as a by-product obtainable from a nuclear reactor. On the formulation of AECL, there appeared to be a growing interest and a potentially large market built around a radio activity technology. Commercial Products was a Division that sold \$10.0 M per annum of goods and services - mostly outside of Canada - for the last seven years. In the last fiscal year, it has grown rapidly to \$18.0 M, and is now projected to be, potentially, \$80.0 M or more by 1980.

What are the goods and services that AECL handles, making Canada a technological leader in this little-known industry spectrum? Can other Canadian companies participate?

5.1 COMMERCIAL PRODUCTS DIVISION - AECL

In the radiation technology industry, Canada currently holds 50% of the world market. The equipment and services are sold by the Commercial Products Division of AECL, and 90% of the sales are made through foreign agents who do not necessarily have technological expertise. During the past year, sales from this Division have demonstrated a dramatic increase, such that the industry is worth examination.

The Commercial Products Division has been under the sole jurisdiction of Roy Errington. In 1952, on the formulation of AECL, it was decided to move this development group from Eldorado Mining into the fold of AECL. For this reason, Commercial Products and Eldorado Mining share common facilities in Tunney's Pasture in Ottawa, and Commercial Products has always remained a division and an entity unto itself.

In 1946, Roy Errington joined Eldorado and established a group to handle the processing and sale of radium, and, subsequently, of radio isotopes. This group designed and introduced Cobalt 60 therapy machines, and installed the world's first commercial unit in 1951; the unit was patented in October, 1951, representing the first of many products to be so established. During the 1940's, it was ascertained that gamma radiation could be used as an effective retardation factor in the treatment of cancer. The most efficient production of gamma rays appeared to be by exciting cobalt by leaving it resident in a nuclear reactor for a period. Eldorado produced the cobalt, utilizing NRC's NRX Reactor at Chalk River to produce the source of the material. Unlike radium, which has an almost infinite half life - and hence, can be the cause of a number of secondary problems if it becomes resident in the human body - cobalt had a five-year half life and was radiating gamma rays as opposed to particles.

The first commercial developments were done in conjunction with General Electric, who had been extremely active in the X-ray technology field. General Electric also became the first of many distributors for AECL, handling these products in the United States. Cobalt 60, from Canada, as a source of medical radiation was already well established at the incorporation of AECL in 1952. In July of 1974, Errington will be retiring and Archie Aikin, a long-time associate will become Vice-President, Commercial Products.

Commercial Products Sales

From 1952 to 1968, Commercial Products sold and developed the therapy radiation treatment units. By 1968, the Division had reached a sales volume of approximately $9.0 M per year, had 700 units installed, and had shipped ten million curies of source material. They had continued to conduct research and development activity insofar as medical and industrial uses for radiation, as well as sterilization possibilities.

Marketing and Marketing Philosophy

The philosophical objective of Commercial Products appears to be targeted at a break-even operation. On $10.0 M worth of sales, the company seems satisfied to generate a $100,000.00 - or a 1% - net return. The company is responsible within its revenues to write off its own land and buildings, to absorb all proportional cost overheads of directors and AECL management who assist in Commercial Product operation; but, within the marketing organization there appears no major thrust or impetus towards profitability.

The market prior to 1970 was mainly confined to hospitals and to therapy-type treatment. Commercial Products chose to market through a series of representatives in the international field, 90% of gross sales being handled in this manner.. The sales were, for the most part, highly technical, and, if a medical staff wished radiation treatment, they were attracted to AECL because of reputation, reliability of equipment, and the length of time in the industry. It is questionable whether a commercial organization would have been able to exhibit the 'stick-to-itiveness' of CP, and possibly would not have had significantly different sales records.

Sales - 1968 to 1972

During the period 1968 to 1972, two new companies took an interest in the Cobalt Teletherapy - Siemans and Picker. They both basically had copied AECL technology and then upgraded their equipment. As a result of intense commercial competition, CP has dropped to about 50% of the world market; at the same time, CP has cut out their planning and market research. CP continues, however, to seek out new products and has tried a number of projects in the market-place. Sales for 1968-72 were static, remaining at the $10.0 M figure despite the fact that each year marketing and management believed next year would see a strong surge.

Director of Marketing during this period had been H.G. (Grant) Gay, a 'go-getter' decision-making man who was basically trained in physics. His assistant was E.K. (Ken) Coltas, a chemist. The market has shown the results of their efforts in 1973, with a jump to $18.0 M in sales, and a 1974 projection of $22.0 M. 1973, however, also showed a $900,000.00 loss in the CP operation. A re-organization is presently underway which divides marketing, production, and product handling of the CP business into three totally separate divisions, and these divisions and their products bear examination. They are Medical, Industrial, and Radio Isotopes.

5.2 AECL COMMERCIAL PRODUCTS, MEDICAL DIVISION

DIRECTOR: H.G. (Grant) Gay

PROJECTED
1974 SALES: $13.5 M

PRODUCTS:
1 Cobalt 60 Teletherapy equipment
2 Teletherapy Accelerators
3 Teletherapy Simulators
4 Cobalt 60 Radiation Source
5 A small research reactor (Slow Poke)

Commercial Products, in South March, manufactures a wide series of radiation equipment designed for various aspects of teletherapy treatment. They appear to maintain a high degree of reliability with good quality control of equipment, and enjoy an excellent reputation in the medical field. The Cobalt 60 equipment includes the Eldorado line, and the more recently developed theratron line. Detailed information is readily available through technical and marketing material.

These units sell in the vicinity of $100,000.00, and utilize Cobalt 60 sources of an intensity of 10,000 curies with an average sale price of 50¢ per curie. The hospital purchasing a principal unit from CP is likely to continue buying their source radiation from that group, giving an average on-going sale of two to three thousand dollars per year, depending on replacement cycles. The equipment in itself is technically well recognized and is marketing through a chain of representatives that have been built up over a number of years in an established pattern.

Accelerators

AECL formed a joint venture with the Accelator Division of Thompson CSF (France) to build and market a line of linear accelerators which will compliment the teletherapy Cobalt 60 line of equipment. These units range from 6 Mev to 40 Mev, and range from about $100,000.00 to $1.0 M. The accelerator provides treatment intensity equivalent to the Cobalt source at the low end, and significantly more powerful at the high end. There is a psychological advantage to the more superior units. AECL had developed, using a PDP 11 Computer, a control capability which allows for charting radiation intensity as the source is rotated around the patient. Interestingly, General Electric did not wish to be the marketing agent for CP in the United States, and hence, CP is doing it directly. CP is optimistic about the potential sales for the accelerator line.

Simulators

Simulators are very low radiation units which allow for patient examination prior to treatment. Many centres use the high-power treatment facilities both for diagnosis and for treatment, hence reducing the overall efficiency. AECL has combination simulators and accelerators, being controlled by a common PDP 11, which provides a highly competitive total treatment facility.

Slow Poke

AECL, for university research purposes, designed a very small research nuclear reactor which markets for $250,000.00.

The reactor has been running successfully in the University of Toronto for the past several years; it is sufficient for universities to do extensive research and experimentation with the particles generated from uranium fission. The University of Jamaica has been most interested in the purchase of such a reactor; however, they have requested financing from CIDA, and such financing has been twice turned down. With Canadian expertise in reactor technology, the universities in many developing nations could be customers for this reactor, especially in light of the significant change in economics of nuclear power and the likely predominance of this technology for power generation in the next 10 to 15 years. Unlike power reactors, research reactors could be sold on a turn-key basis with all of the technical equipment and expertise shipped directly in from Canada.

Turn-Key Cancer Treatment Centres

In the Medical Products Division, the only significant opportunity for a company to develop a business base would be to design, develop, and finance turn-key treatment centres. A typical centre might be in the order of $3.0 M, requiring a combination of engineering and hospital design, installation and maintenance of treatment equipment, construction of facilities, and financing. The proportional values of input to such a centre might be as follows:

1 Site and building - $1.0 M (includes machine shop and labs)
2 Engineering design and project management $200,000.00
3 Cobalt 60 teletherapy units (2) - $400,000.00
4 An Accelerator - $500,000.00

5 A Simulator - $100,000.00

6 X-Ray components and miscellaneous treatment equipment - $500,000.00

7 Miscellaneous equipment, overheads, financing costs - $300,000.00

<u>TOTAL: $3.0 M</u>

A majority of this equipment is manufactured by CP, and could be attained on very attractive terms. They are not in a position to do the engineering design, or finance of the turn-key operation. Brazil has presently allocated $20.0 M for the purchase of such a turn-key operation, and a number of other countries would be more than willing to entertain a proposal if any company had proven expertise in providing such a facility. The Princess Margaret Hospital in Toronto has perhaps the best cancer treatment centre in the world, and Canada is in a strong position to provide all necessary training associated with the centre.

5.3 AECL COMMERCIAL PRODUCTS, INDUSTRIAL DIVISION

DIRECTOR: J. (John) Austi

PROJECTED
1974 SALES: $4.5 M

The Industrial Division offers a potentially limitless horizon of activities. Four directly applicable sources of radio activity are as follows:

1 For sterilization

2 For polemarization (structural change of material)

3 For bacteria retardation or elimination (food products)

4 For an energy source

Each of these applications provides some interesting opportunities, and a few of them significant economic potential. None is more frustrating - but with larger rewards - than in the food area, and if market development dollars were to be spent, the risk-reward relationships in this area could be significant indeed.

The products are straightforward, being basically the irradiators of two types and of varying intensity. At present, the principal source is Cobalt 60; however, some uses are being made with cesium. The irradiators produced by AECL are gamma cell or gamma beam, depending on whether the item to be radiated is placed inside a cell, or within a concrete or lead room and radiated by an open source. The applications are challenging; however, it should be borne in mind that the principal sale is of source radiation and not the equipment.

Sterilization

Over the past dozen years, hospitals have gone increasingly from using glass-based products to plastic products. Bacteria and germs can be efficiently eliminated by irradiation. A major source, however, could process all of the sterilization demands for the city the size of Toronto, as is currently being done. Sterilization uses for radiation might increase, if solely on the grounds that some products which might not otherwise need sterilization can have a better marketability with this label. It is a limited market to those people working in the hospital or clinical laboratory-oriented fields.

Polemarization

When some products are exposed to radiation, they tend to go through discrete structural changes which have tendencies to give them property or physical changes. A most notable example is in the area of wood surface, and AECL, in conjunction with an Ottawa supplier, developed a wood polemarization treatment at South March which provided a unique product. Some radiation equipment was recently sold to Caracas to provide this irradiated wood surface. The net result is a product which has a longer durability and an attractive surface. In the rapidly changing world of building supplies, however, the cost economics of using the highly sophisticated source appears to be more a luxury than a necessity, and no examples have yet appeared in which the irradiated product has an economically superior value based on the process to which it has been subjugated.

Food Processing

Food processing provides the most exciting economic advantages, but the most disconcerting marketing and philosophical problems. Radiation appears to retard or eliminate the vast majority of bacteriological entities associated with food, seeds or associated products. Some peripheral areas of interest are:

1 Radiated seeds in some cases appear to have a faster growth cycle, and hence lend themselves to development in shorter growing periods;

2 Radiated products such as potatoes tend to be retarded from growing sprouts and other such secondary growth phenomena, when maintained in storage;

3 Berries, and other such fruits, maintain shelf life for a considerably longer period after irradiation.

It is perhaps the third discovery that is the most significant, and, even though there are economic advantages in Canada, the major significant area for radiation would have to be all those countries associated with tropical climates. With food becoming a rapidly growing scarce commodity, the world prices of food escalating, ways of preserving and getting longer life between the harvesting and consumption of food are becoming extremely valuable.

In Peru a sterilization process on fish meal is currently undergone, prior to the product being shipped to the United States. This process costs in the vicinity of $8 per ton; that sterilization process can be done more efficiently and effectively at $2 per ton using radiation.

In Chile they estimate that in some areas the yields of food could be doubled; however, the additional food under current circumstances would go to waste because it is destroyed before it can reach the consumers. Some foods can have increased shelf life of five or six months through effective sterilization using radiation.

The Mexicans are proceeding with radiation on wheat at 19 to 20 cents per ton for sterilization, and plan on using two million curies per year, representing a $1.0 M per annum gross sales. There are countless other examples in every tropical area of the world. The sales potentials are in the hundreds of millions of dollars, but it is not within the scope of this report to go into further detail.

The principal problem with irradiating food products is a psychological one. The public -especially in North America - has been conditioned to react against irradiation of any kind. We are aware that environmentalists point to the health hazards of the nuclear reactors, and yet, it is a statistical fact that the radiation received when on site at Douglas Point is less than the additional cosmic radiation received from the increased altitude of standing on the top of the Toronto Dominion Centre! The FCC has placed very stringent regulations on any food stuffs that are to undergo radiation; they have yet to discover any damage, however, they have proved that there is a slight chemical reorientation of potatoes after radiation. This appears to improve the product; however, the fact that the product is altered provides sufficient reason for them to withhold this as a sterilization technique until they have thoroughly exhausted all the potential hazards. Similarily with the fish meal example from Chile, the FCC refused to allow this product sterilized through radiation to be shipped to the United States, which constituted 80% of the Chilean market. Once a major breakthrough occurs in the food processing area, and the psychological hurdle is overcome, the sales potential is significant. CP believe that in the next two to three years, specifically in the tropical areas, this technique will start to become employed.

Energy Source

Cobalt 60 and other radiation products with even -onger half lives, are a continual source of radiation, and AECL has developed a line of inexpensive beacons and location devices using this as an energy source. Such equipment appears to be oriented to government needs, and not, at this time, to have a large market potential.

5.4 RADIO ISOTOPES

DIRECTOR: A.B. (Al) Lillie

PROJECTED
1974 SALES: $4.0 M

CP has developed a wide range of radio isotopes, which are shipped to research facilities throughout the world. After the Cobalt 60, the most significant is Molybdenum 99, and others include Iodine 131, Iodine 125, Phosphorus 32, Carbon 14, and Iridium 192. This constitutes a fairly specialized and unique field to AECL, and it is highly unlikely that any company without their extensive research facilities, their reactors, their handling capabilities, would have any interest in participating in this market.

Conclusions

Commercial Products provides some interesting technological areas, and some significant market potentials. CP sales and the activity from other commercial corporations in the world are certainly worth observing in a few of the specialized areas. Over the past number of years, CP has developed joint ventures to manufacture products in India, Germany, and Italy, and has had no success in any of them. The Indians terminated the agreement and then copied AECL's products and have attempted to deliver them; however, they have not been able to develop working models. In market philosophy, it is interesting to note that AECL discovered a small structural fault in one of their Cobalt 60 processing units, and last year sent a team around the world to dis-assemble and examine every unit that they had in the field to check for a similar structural defect. This exhibits a tenacity for detail not normally accommodatable with a strongly profit-oriented corporation.

THE NUCLEAR INDUSTRY IN CANADA

6.1 INTRODUCTION TO THE CANADIAN NUCLEAR INDUSTRY

Canadian industry has been in the nuclear energy field, as a partner with government agencies, for more than 25 years. Industry involvement in nuclear power stations, based on the CANDU design, began with the 20 Mw NPD station at Rolphton, Ontario. Since that time, many industrial firms have become involved in the construction of the Pickering Generating Station culminating where contracts worth more than $300 M were awarded to approximately 900 companies. The components included some half a million cubic yards of concrete, almost 8,000 piles, 25,000 tons of structural steel, 870 miles of power and control cable, 100 miles of pipes and tubing ranging from less than half an inch to more than nine feet in diameter, 50,000 valves, 900 heat exchanges, and 250 pumps. The capacity and capability of Canadian industry to supply technical knowledge and nuclear components is part of the reason that the CANDU Reactor design concept has proven so successful and today leads the world in performance.

Of the $300 M, approximately $100 M was for the nuclear steam supply system, $65 M for the turbine generator and associated switching equipment, and $170 M for the balance of plant and construction. The component costs of the Pickering Generating Station are summarized on the next page.

For this report, we shall concentrate on the $100 M worth of contracts awarded for the nuclear steam supply system, generally referred to as the NSSS. The NSSS, coupled with the turbine generator and switching equipment, is referred

COMPONENT COSTS OF THE PICKERING GENERATING STATION AS A PERCENT OF TOTAL PLANT COSTS

Component	Cost ($\$ \times 10^3$)	% of Total Costs
Nuclear Steam Supply System	102,102	13.7
Fuel	8,740	1.2
Heavy Water	119,260	16.0
Turbine Generator and Associated Equipment	66,172	8.9
Balance of Plant and Construction	168,562	22.6
Engineering (Field, Hydro and AECL)	73,559	9.9
Interest During Construction*	101,778	13.6
Other Costs	106,097	14.2
TOTAL	746,270	100.0

* Includes commissioning, administration, escalation, inspection, operation and maintenance, and contingencies.

to as the nuclear power supply, commonly shortened to NPS. There are twelve major sub-systems of the NSSS in a CANDU Reactor:

1 Calandria and associated equipment
2 Steam generators
3 End fittings, bearings, bellows and associated equipment
4 Fuel handling systems
5 Tubing
6 Pipes
7 Pumps
8 Valves
9 Heat exchangers, condensers and coolers
10 Tanks
11 Instrumentation and control
12 Other components

The integration of some of these components is illustrated in the following Figure:

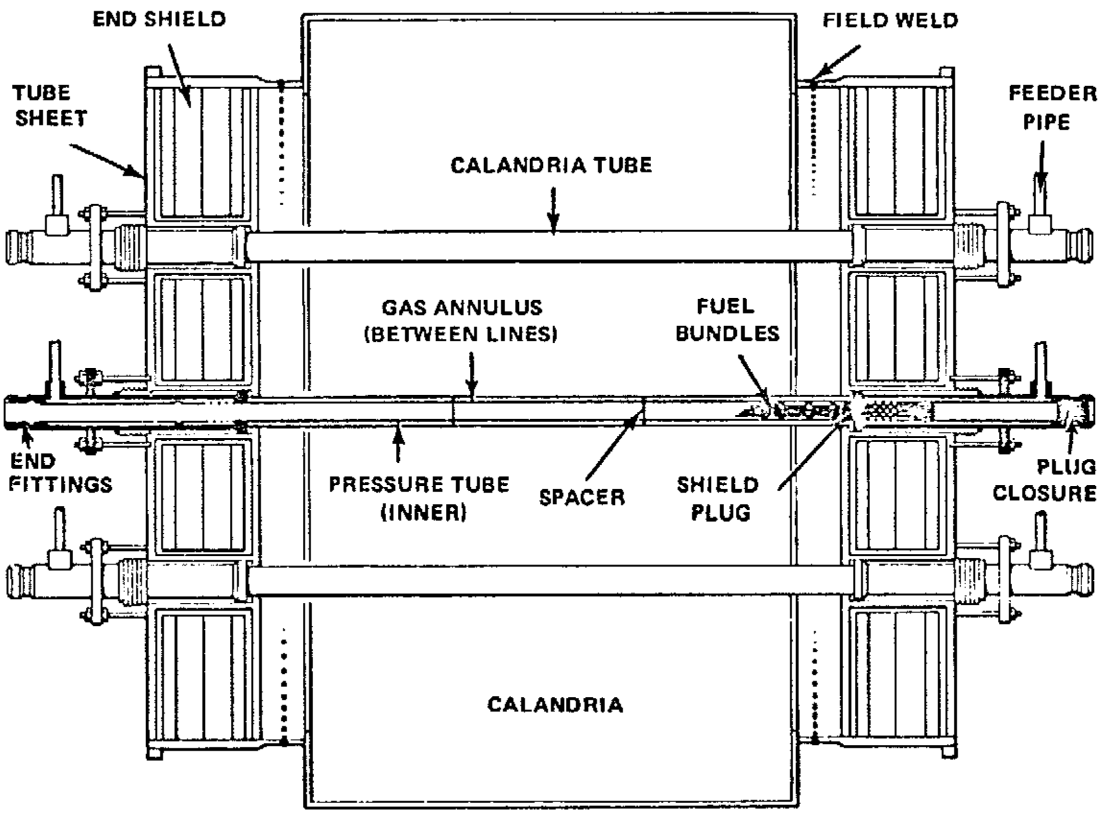


Figure 9 Pickering Reactor Core Schematic

6.2 COMPONENTS OF THE NUCLEAR STEAM SUPPLY SYSTEM

In this section we shall provide a summary description of the major components, the approximate sales volume at Pickering and Bruce, and the identification of the major suppliers. Seventeen companies were awarded contracts in excess of $1 M at either Pickering or Bruce. Another 38 companies were awarded contracts between $100,000.00 and $1 M. Resumes on many of the companies discussed in the following text are introduced in Appendix II.

Calandria and Associated Equipment (including End Shields)

The calandria and end shields represent the heavy engineering component of the CANDU system and may be compared to the pressure vessel in light water reactors. These items represent approximately 15% of the total capital expenditure on the nuclear steam supply system at both Pickering and Bruce Generating Stations, and, together with the end fittings, fuel handling systems, and coolant, pressure, and calandria tubes, are unique to CANDU-type Reactors.

The two major suppliers in this category are Dominion Bridge, which manufactured the calandria for both Pickering and Bruce, and Canadian Vickers Limited who, in addition to some other components, supplied the end shields for both stations. Needless to say, both companies have been awarded contracts in excess of $1 M. Other companies with contracts in this subsystem between $100,000.00 and $1 M at Pickering or Bruce include: Superior Steel Ball, Drummond McCall, United States Steel, and Canadian Westinghouse.

The capital costs for the calandria and associated equipment amounted to approximately $7.50 per Kw output at Pickering while the cost for comparable items at Bruce may be as low as $4.50 per Kw.

If the CANDU concept can be marketed abroad, it could mean considerable business for these two large companies since many of the developing nations do not possess the capability or the capacity for heavy engineering works. Similarly, many countries find it necessary to import pressure vessels upon purchase of a light water reactor system. In addition to the successful bidders on the Pickering and Bruce Generating Stations, the Department of Industry, Trade and Commerce lists Dominion Welding Engineering Company Limited and Marine Industries Limited as companies with the ability to manufacture calandrias. Dominion Welding Engineering and General Gear are indicated as companies with the capability to produce end and thermal shields and support assemblies. All companies supplying components to this segment of this system indicated that reasonable profits and an adequate return on investment will be achieved if forecasted sales materialize.

Steam Generators

Steam generators for both Pickering and Bruce were supplied by Babcock and Wilcox (Canada) Limited. Together, the steam generators at Pickering and Bruce cost $30 M.

The Douglas Point Station had eight boilers, supplied by Montreal Locomotive Works, each with an evaporation rate of 145 mg/h. The twelve boilers at Pickering have been increased to 245 mg/h; those for the Bruce station will be rated at 525 mg/h.

The company noted that sales to date have not been profitable when measured against normal criteria. However, they are considered an investment against future sales. Export sales of this component to developing countries are not expected to be significant since they are of a "one-off" nature, often followed by technological assistance which provides little profit to the company.

The Department of Industry, Trade and Commerce lists MLW-Worthington Limited as major competitor to Babcock and Wilcox (Canada) Limited for the supply of primary system steam generators. Ontario Hydro doesn't. MLW Industries, a division of MLW-Worthington Limited, supplied components for Douglas Point, Gentilly, and the two Rajasthan units. As a point of interest, there are three major suppliers of steam generators for pressurized water or boiling water reactors in the United States - Babcock and Wilcox, Combustion Engineering and Westinghouse.

End Fittings, Bearings, Bellows and Associated Equipment

Contracts in excess of $1 M were awarded to Canadian Curtiss Wright on the Pickering Generating Station, Canada Forgings on the Bruce Station, and to General Gear on both stattions. Some of the other companies working in this area with contracts less than $1 M include Bata Engineering, Canadian General Electric, Philip French Sales Limited, Atlas Alloys, Orenda, Dowty and Canadian Iron Foundaries. Like the calandria and end shields, components in this category are special to the CANDU design. Total cost of the components in this category at Pickering amounted to slightly less than $10 M while the cost at Bruce totalled $7.5 M.

General Gear, one of the major contractors in this area, is a division of Donlee Manufacturing Industries, a totally-owned Canadian company. By the time the Bruce Station is is completed, General Gear will have processed over $10 M worth of nuclear sales in Canada and exports in excess of $1 M. By 1980, based on average cost per Kw, there could be $70 M worth of business in this component alone.

Fueling Systems

The fueling machines, two to each reactor unit at Pickering, permit the reactors to be fueled on-line which is perhaps the single most important reason for the high performance factor achieved in CANDU systems. During the fueling cycle, one machine is connected to act as donor while the second acts as an acceptor, receiving the spent fuel. Rather than two machines for each unit, as at Pickering, or four pairs of machines in all, the Bruce Station will have only two pairs of machines resulting in a considerable saving on these very expensive pieces of equipment.

The total cost of the fuel handling system for Pickering was approximately $18 M or $9.00 per Kw. Fueling machines for Bruce will cost between $6.00 and $7.00 per Kw.

At the Pickering Station, all components were tendered separately resulting in more than 200 separate contracts, the largest contracts awarded to Standard Modern, Taylor Forge, Beaver Precision and Dominion Bridge. However, for the Bruce Station, only a single prime contract was awarded - to Canadian General Electric. Sub-contracts were placed by Canadian General Electric with many of the same suppliers who provided components for Pickering. Ontario Hydro indicated that it was much easier to deal with a single manufacturer in this area rather than to supervise a multiplicity of contracts.

The two companies with the heaviest involvement in fueling machines are Standard Modern and Canadian General Electric. Both are Canadian subsidiaries of foreign companies - Standard Modern being a wholly-owned subsidiary of Staveley Industry Limited of England and Canadian General Electric being a subsidiary of General Electric in the United States.

Forecasting the future sales volume in this area is difficult because sales will not be a function of the size of the reactor unit. Pickering, rated at 2,000 Mw, has eight fueling machines while Bruce, rated at 3,000 Mw will have only four. However, if the sales volume remains somewhere between $6.00 and $7.00 per Kw, by 1980, cumulative sales will have reached $50 M in this area and, by 1990, $250 M to $350 M.

Tubing

Though not a very contiguous group, except that they are all circular, all tubing in the nuclear steam supply system has been aggregated into this one category. At Pickering, the cost for tubing approached $20 M at Bruce $25 M.

The category includes coolant and pressure tubes, reactivity control tubes, shroud tubes, steam generating tubing, bleed coolers, and moderator and calandria tubes. While it would be normal to isolate the zirconium tubing which the CANDU pressure tube design uses more extensively than any other reactor design, it has been combined here with the rest of the tubing since several manufacturers supply more than one type.

There were several contracts awarded at Pickering and Bruce in this category exceeding $1 M. While Canada is potentially self-sufficient in primary alloy billets, only the seamed calandria tubes are manufactured domestically, by Canadian Westinghouse. All the other large sales were to foreign companies including Chase Brass and Copper, Vereinigte Deutsche, Pacific Tube, and Carpenter Steel. Pacific Tube is a wholly-owned subsidiary of Superior Tube, a private company Chase Brass and Copper is a division of the Kennecott Copper Corporation. It has been announced recently that Chase Brass and Copper will open a division in Canada. Other world suppliers include Sandvik Steel, Ugine-Kuhlmann, and Wolverine Tube - a division of Calumet and Hecla.

Pipes and Headers

This category includes main circuit feeder pipes, headers, feeder couplings, and other miscellaneous pipes and fittings but excludes orders of pipe used on the job. Contracts in excess of $1.0 M were awarded to Dominion Bridge and Taylor Forge. Companies with contracts in excess of $100,000, but less than $1.0 M include Mitsui & Company, Crane Canada, Gray Tool, Canadian Vickers, Silbo Sales, and Myatt-E and Company. The Total value of sales at Pickering amounted to $4.0 M, or approximately $2.00 per Kw output. At Bruce, the unit cost was slightly higher at $2.10 per Kw. For the most part, there was no change in suppliers between the four units at Pickering and those at Bruce. None of the components in this category are special to the CANDU concept.

Pumps

The Douglas Point Station contains ten pump motors, each with a rating of 930 Kw. These pumps were the cause of substantial difficulties. This learning experience, and extensive testing prior to servicing, has resulted in excellent performance from the 16 - 1400 Kw pumps per unit at Pickering. There has been considerable speculation on how the pumps at the Bruce Generating Station which are rated at 8200 Kw will perform.

The large pump manufacturers in Canada include Byron Jackson, Bingham Pumps, Babcock Wilcox, and Canadian Ingersoll Rand. Bingham Pumps and Byron Jackson also have significant sales in the United States. All these companies have been awarded contracts in excess of $100,000. Contracts to Byron Jackson and Bingham Pumps have exceeded $1.0 M.

The pumps at Pickering include the moderator circulating pumps, feed and bleed pumps, cooling water circulating pumps, boiler feed pumps, and dewatering pumps, for a total of $8.0 M, or $4.00 per Kw. Similar pumps at Bruce will cost approximately $13.0 M, or $4.40 per Kw. While there is no saving in capital cost due to the increase in pump size, it is expected that savings will accrue through a reduction in maintenance costs. The large sales in this category are for the primary coolant pumps supplied by Byron Jackson.

Valves

This category includes all valves in the nuclear steam supply system such as butterfly, check, control and gate valves. Contracts at Pickering total $3.8 M; those at Bruce total $3.5 M.

Companies with major contracts include Persta International, Aviation Electric, Peacock Brothers, Guelph Engineering, Canadian Vickers, Velan Engineering, and Lytle Engineering (an exclusive distributor for Velan). The only company to recieve a contract in excess of $1.0 M in this area was Peacock Brothers for the four units at Bruce.

Other companies with capabilities in this category include Dominion Engineering Works Limited, Keystone Valve (Ltd.), Welmet Industries Limited, Fisher Controls of Canada Limited, Masonellan, Singer Valve Company Limited, Farris Industries (Canada) Limited, Manning, Maxwell, and Moore Division of Dresser Industries (Canada) Limited and Yarway (Canada) Limited. Many of these companies are 100% Canadian controlled while others act as sales agents for valve manufacturers in the United States or England. There have been complaints in this area that contracts have been awarded to companies outside Canada when competitive bids have been submitted by Canadian companies with experience and capabilities in this area.

The Canadian valve manufacturers reported a very high Canadian content in labour, raw material and sub-assemblies. Sales have generally been profitable and this is expected to continue. In addition, there has been an adequate return on invested capital largely due to the fact that many of the valves are not designed solely for nuclear power plants but are standard items with slight modifications.

By 1980, the cumulative sales volume in this area should reach $7.0 to $10.0 M. However, because of the number of companies with capabilities in this area, competition should be very active.

Heat Exchangers, Condensers, and Coolers

This category includes heat exchangers for the moderator, colandria and end shields. Of all the companies awarded contracts in this area, only MLW Worthington received a contract in excess of $1.0 M - for the moderator heat exchangers at the Bruce Generating Station. Companies with contracts between $100,000 and $1.0 M in value include Toronto Iron Works, American Standard Products, Canadian Vickers, Montreal Locomotive, Foster Wheeler, Unifin and Keeprite Products. The cost of heat exchangers for Pickering was approximately $3.0 M, the same as for Bruce. Heat Exchangers for the CANDU system have, for the most part, been designed solely for this market. Sales appear to have been profitable and have provided an adequate return on investment. This should continue into the future.

Tanks

This is a very small category. The total sales value at Pickering was $1.2 M, but at Bruce, only $150,000. The major companies in this area include Dominion Welding Engineering, Davie Shipbuilding and Horton Steel Works Limited. The tanks, which are used to dump the moderator in case of emergency, have been replaced at Bruce with poison injection controls.

Instrumentation and Control

The most significant item within this category is the computer used for monitoring and control. Pickering has two IBM 1800's for each unit. A unit cannot operate if both computers are inoperative. Capital expenditure for instrumentation and control has been approximately the same for each generating station - $3.5 M. IBM was a successful bidder on all four units at Pickering; CAE Electronics was the successful bidder at Bruce. These products are generally standard items with monor modifications to suit particular customers. In addition to the more glamourous computer hardware, other instrumentation and control equipment in this category includes detection devices, analog units, and monitoring and recording instruments. Companies already competing in the field include Fischer and Porter (Canada) Limited, the Foxborough Company Limited, Orenda Limited, Sigma Instruments (Canada) Limited, Advanced Transducer Systems Limited, and Reuter-Stokes (Canada) Limited. This area also includes in-core flux detector systems including shut-down and control systems. Total sales through 1971 in this area amounted to about $1.0 M for these companies (i.e. excluding the computer hardware and software.) These sales have generally been profitable and have provided adequate returns on investment. This situation should continue with forecasted sales volume.

Other Components

In addition to the major components discussed to this point, there are a variety of other items that do not fit a single category, but, when taken together, constitute a major expenditure. At Pickering the total cost of these other components amounted to $6.0 M, and included items such as penetration and air locks, vacuum ducts and a pneumatic messenger tube system. At Bruce, components included items such as boiler supports, loose shielding, and shut-off and booster drives. Contracts totalled $6.5 M. Some of the companies in this area include Dominion Bridge, Canadian General Electric, Bata Engineering and Dominion Aluminum Fabricators.

6.3 VIABILITY OF THE CANADIAN NUCLEAR INDUSTRY

With the exception of zirconium tubing and the raw material required in the fabrication of heavy stainless steel plate for the calandria, the capability to supply all components of the CANDU system exists within Canadian industry. Many manufacturers indicated that a continuing nuclear power program is necessary for the survival of the industry. However, with the exception of a few of the heavy engineering components, the companies have not committed a large proportion of their sales to the nuclear power market. Many of the manufacturers, particularly those who designed the components unique to the CANDU system, are still in the learning curve with respect to the production of components and while few are achieving corporate profit objectives, most have a desire to remain active in the nuclear power market, especially when the industry has dedicated more than $30.0 M to capital equipment for the manufacture of components for CANDU Reactors. Should the forecast of installed capacity in Canada (38,000 Mw by 1980) be realized, this would provide sufficient sales volumes to generate acceptable profits for those companies participating in the market.

At present, no company is dedicated or has a major portion of their sales devoted to the nuclear power market. Until a stabilized situation is achieved through an increased commitment by Canadian utilities to nuclear power generated by CANDU Reactors, this situation is not expected to change. Excluding the heavy engineering components such as calandria and end shields, no company devoted more than 10% of the sales to the nuclear market and most averaged between two and five percent. Therefore, even if the market did not reach significant levels within the next few years, then the manufacturing capability in Canada would not be in jeopardy. The industry would simply switch their production from nuclear sales until such time as orders were received and scheduled into the plant.

A significant problem exists however for the Canadian companies with five to 10 percent of their production in the nuclear field. AECL and Ontario Hydro have insisted upon unusually high quality assurances over and above those attainable in commercial sales; if a company is to shift over, abnormal costs exist. This condition is exhibited by reviewing those companies listed as being able to provide components and the companies considered by Ontario Hydro as adequate suppliers in fields such as valves.

6.4 FACTORS AFFECTING THE GROWTH OF THE NUCLEAR INDUSTRY

In the previous section, we concluded that the capability of Canadian industry to supply components for a CANDU Reactor would not be seriously jeopardized through a lack of sales in the immediate future. However, the reverse is not necessarily true.

If forecasts on installed generating capacity recently released by the Canadian Nuclear Association and AECL are realized, then, by 1990, there will be 38,600 Mw of installed nuclear generating capacity in Canada, 32,000 of which would be installed between 1980 and 1990. This would represent a total investment in nuclear power plants of $20.0 billion and even this could be increased if the rate of inflation proves greater than economies realized through increased size and quantity.

With competing projects such as the Tar Sands Development, expansions in the petro-chemical field, Northern Development and the major pipeline projects, it may be very difficult to find sources of funding for nuclear power development. Furthermore, while many of the manufacturers indicated that they could supply components to meet the short term forecasts of installed capacity, additional capital investments will be required if Canadian industry is to provide the same proportion of components as was provided to the Pickering and Bruce generating stations. This expansion could require an additional capital investment of up to $50.0 M; in addition, another $500 M will be required to increase heavy water production facilities. These numbers are almost too great for comprehension and they represent only one sector of the energy market.

Perhaps of greater importance will be the lack of qualified manpower. Two years ago, during the work of Task Force Hydro, the manufacturers indicated that obtaining qualified manpower would not be a problem except in some specialized areas such as welding and quality control to nuclear standards. Today, several companies are talking about being unable to hire engineers and technicians. Syncrude has indicated a requirement for several hundred engineers over the next few years.

In summary, should the financing and manpower be available, the nuclear power market could become very profitable within the next few years as the prospect for fusion and breeder reactors becomes more distant. The projected growth of installed capacity increases significantly. In 1971, the Canadian Nuclear Association forecasted an installed capacity for Canada of 35,000 Mw; today that projection has grown to 38,000 Mw.

The impact of this projected growth on potential sales in the various major components of the nuclear steam supply system will be discussed in the following section.

6.5 POTENTIAL SALES IN THE NUCLEAR STEAM SUPPLY SYSTEM

In section 4.2, we discussed the most recent projection prepared by AECL (January, 1974) of installed nuclear capacity in Canada. An expression of the approximate cost of the various components of the nuclear steam supply system, qouted in terms of $ per Kw output, is presented on the following page. Excluding the tanks, which will no longer be required in the CANDU design, applying the average unit cost derived from above to the projected installed capacity from section 4.2, provides an estimate of the potential sales for the various components of the nuclear steam supply system. The results of this analysis are presented in the following tables.

These forecasts do not include potential export sales. Further while the projected capacity for 1985, for example, is 17,000 Mw, contracts for the components will be awarded several years in advance - in some cases up to five years before the in-service date.

In the following text, we shall discuss the possible market conditions for some of the components of the nuclear steam supply system in view of the projected sales levels.

The market for the calandria and end shields, perhaps the most capital intensive item in the nuclear steam supply system, will increase from $35.0 M by 1980 to almost $80.0 M by the year 2000. Dominion Bridge and Canadian Vickers should continue to be the major suppliers in this area. Canadian General Electric, Canadian Steel Foundries (a division of Hawker Siddeley), and Davie Shipbuilding have supplied components for the calandria and end shields but mainly in export markets. With this experience, they too will probably share in this segment of the market.

The two major companies competing for the sales in steam generators for CANDU Reactors are Babcock and Wilcox and MLW Industries. They should share the market, with Babcock and Wilcox maintaining by far the largest portion. The comparable market in the United States is expected to reach $160.0 M by 1980. With the parent company of Babcock and Wilcox in the United States expected to capture a portion of this market, this should provide an increased technical base for their Canadian subsidiary.

The market for end fittings, bearings, bellows and associated equipment should expand from $25.0 M by 1980 to almost $1.0 billion by the end of the century. Some estimates place the market in this category at $100.0 M by 1980, but on a kilowatt basis this appers to be totally unreasonable. General Gear is the largest supplier in this area providing calandria support rods, end fitting bearing sleeves, end fitting linear tubes, fueling machine gear boxes, journal rings, plugs for the end fitting enclosure, reactivity control units and general subcontract machining.

Following the award of the single contract in fueling machines to Canadian General Electric, Ontario Hydro was severely criticized for its change in purchasing policy. Many of the larger subcontractors for the fueling machines at Pickering, notably Standard Modern, were effectively shut out of the bidding. In future, it appears that Ontario Hydro will divide the fueling machine system into a few identifiable subsystems and award separate contracts for each. Ontario Hydro would then assume the responsibility for acting as prime contractor. It may be that Canadian General Electric was awarded the prime contract on the Bruce Generating Station as a 'reward' for their efforts in the design and development work of the new system.

The largest single component of the nuclear steam supply system is the tubing, with forecast cumulative sales of $53.0 M by 1980, and over $1.0 billion by the year 2000. There are three major types of tubing in a CANDU Reactor: coolant and pressure tubes, steam generator tubing, and calandria tubes. All but the calandria tubes are manufactured outside of Canada.

Almost one-quarter of the forecasted sales volume will be for pressure tubes fabricated from an alloy of zirconium.

Another part of the reactor structure fabricated from a zirconium alloy is the calandria tube. These tubes form an integral part of the heavy water moderator system. The calandria tubes are fabricated from Zircaloy-2, a zirconium alloy containing small amounts of tin, iron, chromium, and nickel. The tubes are formed from cold rolled strips and longitudinally seam welded. The market for calandria tubes will be approximately half that for coolant tubes. The third component fabricated from zirconium alloy is the cladding and structural material used in fuel bundles. This component is Zircaloy-4. The market for this type of tubing will be approximately the same as for the coolant and pressure tubes.

Chase, Brass and Copper are the main manufacturers of coolant and pressure tubes. Westinghouse manufactured the calandria tubes for Units 3 and 4 at Pickering, and the four units at Bruce. The Chase Brass and Copper Company recently announced plans to build a plant for the manufacture of zirconium tubing in Canada.

Sales of steam generator tubing are expected to reach $35.0 M for the five year period between 1976 and 1980, and $170.0 M for the five year period ending in 1995. Steam generator tubing is manufactured from Incoloy 800 (previously from Inconel 800). Past sales have been awarded to Vereinigte Deutsche and Pacific Tube.

Several companies provided pipe for the Pickering and Bruce Stations and, since the components are not special to the CANDU design, competition probably will remain active for the $12.0 M in sales expected by 1980 and the $256.0 M by 2000. Byron Jackson have captured the major portion of the market for pumps, and while Ontario Hydro recognize their technical competence, they expressed a desire to have Gingham Pumps improve their product to provide more effective competition.

To date, most of the contracts for valves have been awarded to companies outside Canada, and this policy has been severely criticized by many of the suppliers in Canada. Ontario Hydro countered by noting that while the technical capability exists, ineffective management often results in schedules not being met.

APPROXIMATE COMPONENT COST OF THE NUCLEAR
STEAM SUPPLY SYSTEM (NSSS) PER KILOWATT OUTPUT *

Components of the NSSS	Pickering (2000 Mw)	Bruce (3000 Mw)
Calandria and Associated Equipment	$ 7.50	$ 4.50
Steam Generators	5.00	5.50
End fittings, Bearings, Bellows, and Associated Equipment	4.50	2.50
Fuel Handling Systems	9.00	5.00
Tubing	9.00	8.50
Pipes	2.00	2.00
Pumps	4.00	4.50
Valves	2.00	1.00
Heat Exchangers, Condensers and Coolers	1.50	1.00
Tanks	.50	.00
Instrumentation and Control	2.00	1.00
Other Components	3.00	2.00
TOTAL COST PER KILOWATT	$50.00	$37.50

* rounded to the nearest $0.50

ESTIMATE OF POTENTIAL CUMULATIVE SALES OF COMPONENTS OF NUCLEAR SUPPLY SYSTEM

Components of the NSSS	Cost per kw 1/	Approximate Potential Cumulative Sales 1980 (6,050 Mw)	1985 (17,000 Mw)	1990 (17,000 Mw)	2000 (128,000 Mw)
Calandria and Associated Equipment	$ 6.00	$ 36m	$102m	$230m	$768m
Steam Generators	5.25	32m	89m	203m	672m
End Fittings, Bearings, Bellows and Associated Equipment	3.50	21m	60m	135m	448m
Fuel Handling Systems	7.00	42m	120m	270m	896m
Tubing	8.75	53m	149m	338m	1,120m
Pipes	2.00	12m	34m	77m	256m
Pumps	4.25	28m	72m	164m	544m
Valves	1.50	9m	26m	58m	192m
Heat Exchangers, Condensers and Coolers	1.25	8m	21m	48m	160m
Instrumentation and Control	1.50	9m	26m	58m	192m
Other Components	2.50	15m	43m	97m	320m
TOTAL	$43.50	-	-	-	-

1/ average from Pickering and Bruce.

6.6 THE CANADIAN NUCLEAR ASSOCIATION

The Canadian Nuclear Association was established in 1960 to promote 'the orderly and sound development of nuclear energy for peaceful uses in Canada and abroad.' The membership of CNA includes government, utilities, consulting firms, producers of essential materials, manufacturing firms, transportation companies, financial institutions, labour organizations, educational institutions and individuals who are, or expect to be, engaged in some phase of the development or utilization of nuclear energy.

One of the main aims of the association is to encourage co-operation between various industries, utilities, educational institutions, government departments and agencies, and other authoritative bodies which have an interest in the development of nuclear power and uses of radioisotopes and uranium. Through its standing committees which are active in the field of Codes, Standards and Practices, Economic Development, Education and Man-power Training, International Affiars, Nuclear Insurance, Nuclear Safety, Public Relations and Publications, the association provides an opportunity to analyse industry problems, liaison between industry and governments, information to the public, examination of technical, economic and related matters, and sponsorship of conferences, and seminars on nuclear energy and radioisotopes. Annual membership fees range from $250.00 to $2,500.00 depending on the size of the organization and its degree of involve-ment in the nuclear field. Associate categories of member-ship exist for foreign based members and other organizations with a limited connection in Canada's nuclear industry, and for educational establishments. As of October, 1971, the latest date for which a list was available, the membership included most of the significant participants in the nuclear power market including Dominion Bridge, Canadian Vickers, Denison Mines, Canadian General Electric, Babcock and Wilcox, and Byron Jackson. Several large firms not resident in Canada are also members such as Chase Brass and Copper, Tokyo Electric Power Company and Rio-Tinto Zinc. Several government departments are members. Many of the provincial utilities belong, as well as foreign power companies including France, The United Arab Republic, Japan, Taiwan, Australia and India. Completing the list are organizations such as banks, nuclear consultants, and educational institutions.

In discussions with AECL, their marketing representatives indicated that the Canadian Nuclear Association has not utilized its full effectiveness. It was indicated that in several instances AECL has attempted to encourage and assist CNA but its overtures have been dismissed. Perhaps the CNA finds it difficult to adopt a singular position since it includes both suppliers such as Dominion Bridge and Canadian General Electric, and purchasers such as the provincial utilities. Therefore, while perhaps not an effective lobbying group, the CNA undoubtedly provides a forum for discussion between manufacturers and purchasers.

6.7 THE LEGISLATIVE UMBRELLA FOR NUCLEAR ENERGY

Under the terms of the British North Ameria Act of 1867, ownership and control of resources were vested in the provinces. Uranium is an exception: all ownership still remains within provincial jurisdiction. However, control became the responsibility of the Federal government once the Atomic Energy Control Act had been promulgated in 1946. The authority for establishing such federal controls is contained in Section 92, 10 (c) of the British North America Act.

Nuclear energy is a result of a technology that effectively evolved and was developed during the Second World War. At that period the Federal government was particularly strong. The events associated with nuclear energy which terminated the War clearly designated this as an area of national security, and through the Atomic Energy Control Act, the Federal government - specifically under C. D. Howe - designated within their jurisdictional control all matters associated with the new field. The Act defined prescribed substances - meaning uranium, thorium, plutonium, neptunium, deuterium, and their respective derivatives and compounds, and any substance that the Board may by regulation designate as being capable of releasing atomic energy, or as being requisite for the production, use or application of atomic energy.

The Act, in Section 9, authorized the Board to make regulations for encouraging and facilitating research and investigations with respect to atomic energy, and:

1 For developing, controlling, supervising and licensing the production, application, and use of atomic energy

2 Respecting mining and prospecting for the prescribed substances

3 Regulating the production, import, export, transportation, refining, possession, ownership, use or sale of prescribed substances.

The Act further stated, in Section 10, that the Minister may:

1 undertake, or cause to be undertaken researches and investigations with respect to atomic energy

2 prepare for the utilization of atomic energy

3 expropriate mines, deposits or claims of substances, or patent rights relating to atomic energy;

4 sell or otherwise dispose of discoveries, inventions, or improvements therefore.

And, further, the Minister may:

1 procure the incorporation of any one or more companies for the objects and purposes of performing the above powers.

Under these powers, the Federal Government has created Atomic Energy of Canada Limited, Eldorado Nuclear Limited, and U-CAN Limited. It has maintained jurisdiction to oversee and control activities specifically in the exploration, development and sale of uranium, and further to promote the sale internationally, on behalf of Canada, of the results of the developments of the Canadian nuclear program. .

Atomic Energy of Canada Limited was specifically incorporated as a private company on February 14, 1952, and recorded on March 4, 1952, under the then Secretary of State, Frederick

Gordon Bradley. Under its letters patent, it was to exercise and perform on behalf of the Atomic Energy Control Board such of the powers confered upon the Board by Paragraphs (a), (b), (c), and (h) of Section 8 of the Atomic Energy Control Act, 1946, as the Atomic Energy Control Board may from time to time direct.

With seven members of its initial Board of Directors, including its first president, Chalmers Jack Mackenzie, AECL was underway.

Ontario Power Jurisdiction

The Ontario Hydro operates as an electric utility under the Power Commission Act of 1906, which gave to the Commission wide powers for the generation and distribution of electric power throughout the Province of Ontario. Under these jurisdictions, Ontario Hydro is within its bounds to develop and construct nuclear generating facilities for the production of electric power, to supply their needs. They are specifically prohibited from selling electric power outside of the boundaries of Ontario, except through the grid system.

The Government of Canada has, from time to time, reiterated its specific concerns that the Canadian nuclear industry remain under the control and direction of Canada. To this end, in March 1970, the Government announced that, if necessary, ammendments to the Atomic Energy Control Act would be implemented to limit aggregate foreign ownership of any uranium property of established production capacity to

33%, with a limit of 10% of any one foreign investor or group of associated investors.

Although not publically stated, a number of people formerly associated with General Electric believe that Atomic Energy of Canada, under the direction of the Minister, took specific steps to ensure that Canadian General Electric, a subsidiary of a foreign corporation, would not be the sole supplier of engineering expertise in the nuclear portion of the CANDU Reactor. CGE subsequently withdrew from the market, and AECL has remained as the prime nuclear consultant.

APPENDIX I

CAPSULE BIBLIOGRAPHY OF SENIOR OFFICERS

IN

ATOMIC ENERGY OF CANADA LIMITED

NAME: J. Lorne Gray

POSITION: President

BORN: Brandon, Manitoba, March 2, 1913

EDUCATION: University of Saskatchewan - B. Eng. (1935
- M.Sc. (1938)

CAREER: Having spent five years in the Air Force, three years in private industry, and one year with the National Research Council of Canada, Mr. Gray became Chief Administrator at Chalk River in 1949. In 1952, he was appointed General Manager of AECL, becoming Vice-President (Administration and Operations) in 1954, and President in 1958.

Mr. Gray has received several honourary degrees from the Universities of British Columbia and Saskatchewan. Serving at present as the Chairman of the Board at Carleton University in Ottawa, he is also a member of the Association of Professional Engineers of the Province of Ontario, and of the Engineering Institute of Canada.

NAME: Archie M. Aikin

POSITION: Vice-President

BORN: Saskatoon, Saskatchewan, February, 1918

EDUCATION: McGill University - B.Sc. (1941)
- Ph.D. in chemistry (1949)

CAREER: Since 1949, when he joined the predecessor of AECL, Mr. Aikin has been constantly involved in atomic energy development. Prior to his appointment as Vice-President, his expertise included involvement in chemical engineering, nuclear fuels, and economic evaluations of nuclear power systems. He headed two divisions at Chalk River prior to his appointment as General Manager, Nuclear Power Marketing.

Mr. Aikin is a professional engineer, a member of APEO, a Fellow of the Chemical Institute of Canada, and a member of the Canadian Society for Chemical Engineering.

NAME:	Roy F. Errington
POSITION:	Vice-President Commercial Products
BORN:	Goderich, Ontario
EDUCATION:	University of Toronto - B.Sc. (1939) - M.A. (1940)
CAREER:	Having been active in the field of geophysical and geochemical research, Mr. Errington was engaged in radar production work at Research Enterprises Limited from 1942 to 1946. At this time, he joined Eldorado Mining, where he headed up a group handling processing and sale of radium and radioisotopes. When the operation was transfered to AECL in 1952, Mr. Errington became Manager of the Commercial Products Division. He was appointed to his present position in 1963.

NAME:	John S. Foster
POSITION:	Vice-President Power Program
BORN:	Halifax, Nova Scotia, 1921
EDUCATION:	Nova Scotia Technical College - B. Eng. (Mech) - 1943 - B. Eng. (Elec) - 1946
CAREER:	As part of Montreal Engineering Company from 1946 to 1966, Mr. Foster worked on engineering for thermal power plants, the design work for the NRX Reactor at Chalk River, the feasibility study on the Nuclear Power Demonstration Station, and did design work for this project

while on loan to Canadian General Electric in 1955. In 1958, he became Deputy Manager, Nuclear Power Plant Division of AECL, and Manager in 1958. In 1963, he received the appointment as General Manager of Power Projects for AECL, resigning from Montreal Engineering in 1966 to become Vice-President, Power Projects. In 1973, he was appointed to his present position.

Mr. Foster has received honourary doctorates of engineering from both the Nova Scotia Technical College and Carleton University, and served, from 1970 to 1973, as the Lieutenant Governor's Appointee on the Council for the Association of Professional Engineers of the Province of Ontario.

NAME:	Les R. Haywood
POSITION:	Vice-President Heavy Water Projects
BORN:	Saskatoon, Saskatchewan, March 18, 1919
EDUCATION:	University of Saskatchewan - M.Sc. (1940)
CAREER:	After lecturing in Physics at the University of Saskatchewan from 1945 to 1947, Mr. Haywood joined the predecessor of AECL in 1945, becoming Supervisor of the Electrical and Instrumentation branch at Chalk River. In 1955, he joined Canadian General Electric and was appointed Manager of Fuels and Materials in 1959. 1961 saw his return to AECL as Manager of Reactor Development projects; he was appointed Vice-President, Engineering in 1963, Vice-President, Chalk River Nuclear Laboratories in 1967, and Vice-President, Heavy Water Projects in 1971 - his present position at AECL.

NAME: Ara J. Mooradian

POSITION: Vice-President
Chalk River Nuclear Laboratories

BORN: Hamilton, Ontario, 1922

EDUCATION: University of Saskatchewan - M.Sc. (1945)
University of Missouri - Ph.D. (1950)

CAREER: From 1950 to 1963, Dr. Mooradian was at the Chalk River Nuclear Laboratories, where he worked on plutonium separation, developing the fuels for Canadian research and power reactors; in 1963, he was made Director of the Development Engineering Division. In 1966, he was appointed Managing Director, Whiteshell Nuclear Research Establishment, became Vice-President, Whiteshell Laboratories in 1969, and was appointed to his present position in 1971.

Dr. Mooradian served as the first mayor of Deep River, Ontario.

NAME: Robert G. Hart

POSITION: Managing Director
Whiteshell Nuclear Research Establishment

BORN: Dresden, Ontario

EDUCATION: University of Toronto - B.A. (Phys. Chem.) 1948

CAREER: Joining AECL at the Chalk River project in 1948, Mr. Hart worked on various projects including the purification of heavy water, reprocessing of nuclear fuels, the physical properties of nuclear fuels, and fission product distribution. In 1965, he became head of the Reactor Core Technology branch at Whiteshell Laboratories, was appointed Director of the Applied Science Division in 1969, and, in 1973, was appointed to his present position.

NAME:	Donald Watson
POSITION:	Vice-President Administration
BORN:	Bristol, England, May 19, 1919
EDUCATION:	Oxford University - B.A. (Physics) 1940 - M.A. 1945
CAREER:	From 1940 to 1946, Mr. Watson was with the Telecommunications Research Establishment, both in England and in Bombay, India. In 1946, he came to Chalk River as the Administrative Officer of the United Kingdom staff; in 1948, he became Assistant to the Research Director of the National Research Council, transferring to the Canadian staff in 1950. Mr. Watson became Secretary of AECL in 1956, and was appointed to his present position in 1963.

NAME:	Ed DesLauriers
POSITION:	Treasurer
BORN:	Montreal, Quebec, February 5, 1919
EDUCATION:	Ecole des Hautes Etudes Commerciales - B.A. (1950) Received C.A. Degree in 1953
CAREER:	After serving in the financial end in a number of Canadian companies from 1952 to 1971, Mr. DesLauriers joined AECL in his present position in 1972.

NAME: Angus H. M. Laidlaw

POSITION: Secretary and General Counsel

BORN: Ottawa, Ontario, February 22, 1918

EDUCATION: Queen's University - B.A. (1939)
Osgoode Hall - Barrister at Law (1947)

CAREER: Following his graduation from Osgoode Hall in 1947, Mr. Laidlaw entered the Federal Department of Justice as Advisory Counsel. In 1954, he was appointed Superintendent of Bankruptcy, and was appointed General Counsel, Canadian Broadcasting Corporation in 1955. Mr. Laidlaw joined AECL in his present position in 1961.

APPENDIX II

RESUME OF COMPANIES WITH SALES IN EXCESS OF $100,000 FOR THE PICKERING OR BRUCE GENERATING STATION

COMPANY: Babcock & Wilcox Canada Limited

LOCATION: Coronation Boulevard
Galt, Ontario

Babcock & Wilcox is Canada's largest boiler maker, and is a major producer of nuclear steam generating equipment as well as various lines of utilities pumps. The company is one hundred percent owned by Babcock & Wilcox Company in the United States. There is also a British firm of the same name. Bobcock & Wilcox Canada began as the principal supplier of heat exchanger and steam generation equipment to Canadian nuclear installations when it produced u-shaped heat exchangers for the Chalk River research project. Subsequently it provided the steam drums and other vessels for the Gentilly CANDU-BLW prototype. Ontario Hydro, a major customer for conventional steam generators built by Babcock & Wilcox, has made the largest purchases of nuclear heat exchangers fabricated in the Galt plant. At Pickering, 48 individual units were installed.

The Babcock & Wilcox pump department manufactures a range of condenser cooling, nuclear and condensate pumps. In 1971, Babcock & Wilcox had 2,171 employees.

COMPANY: Dominion Bridge Company Limited
(Industrial Products Division)

LOCATION: P. O. Box 280
Montreal 3, Quebec

The Industrial Products Division of Dominion Bridge is part of an international organization which had sales in excess of $230.0 M in 1972. The company designs, fabricates and distributes a wide range of steel products including structural steel work, plate work and boilers. There are over 7,000 employees located in 19 plants in Canada and five outside the country. Dominion Bridge has played nothing less than a spectacular role in the critical fabrication of major components for the CANDU Nuclear Reactor. Its experience was the most vital asset when building the 60-ton stainless steel reactor vessel for Canada's full-scale nuclear power plant at Douglas Point.

The company also fabricated the calandria shells for the four units at Pickering and the four bought by Ontario Hydro for the Bruce generating station. In addition, Dominion Bridge supplies air locks and feeder pipes for these two large generating stations.

Dominion Bridge has also acted as a sub-contractor for the fueling machines. It provided the columns and bridges for the reactor area at Pickering and is producing the columns and bridges to be used for the Bruce fueling machine reactor in service areas. Furthermore, the company regards such products as pressurizers and steel generators well within its capability.

Other activities have included end shields, water-cooled thermal shields, live steam re-heaters and a shield tank for the RAPP project in India, and air lock alterations for Kanupp in Pakistan.

The company's most reputed achievement in nuclear work was the fabrication of a zircaloy calandria for the Taiwan research reactor. This calandria was the first of its type in the world.

Dominion Bridge is almost one hundred percent Canadian owned, with Algoma Steel holding almost fifty percent of the company. The Industrial Products Division conducts approximately $25.0 M worth of business each year.

COMPANY: Canadian Vickers Limited

LOCATION: 5000 Notre Dame Street East
Montreal 404, Quebec

Canadian Vickers is active in many areas of equipment design and manufacture. It was Canadian Vickers who built the all-aluminium calandria for the AECL experimental NRU Research and Test Reactor at Chalk River in 1957. Since that time, Canadian Vickers has figured prominently in every nuclear power project in Canada. It supplied the calandria vessel and thermal shield assembly, and heavy water heat exchangers for the Gentilly station, the end shield ring assemblies, fueling machine carriages, spent fuel transfer systems, and tanks for Douglas Point, and eight end shields, bleed cooling heat exchanger and pressure relief valves for Pickering.

Canadian Vickers has contracted to supply the complete reactor assemblies, main heat transfer piping, and 16 main pressure relief valves for Hydro's Bruce generating station. Each of the four shop-assembled calandria shield tank assemblies weighs close to 1100 metric tons. In addition to these activities the company has also been a major component supplier to CANDU systems abroad. While being a subsidiary of the well-known British engineering and ship building company, the Canadian operation maintains one hundred percent of its operation.

COMPANY: Canadian Curtiss-Wright Limited

LOCATION: 500 Carlingview Drive
Rexdale, Ontario

While listed as a company interested in sub-contract machining to nuclear quality control standards, Canadian Curtiss-Wright acts as a sales agent in Canada for its parent American company.

COMPANY: General Gear Company
Division of Donlee Manufacturing Industries Limited

LOCATION: 9 Fenmar Drive
Weston, Ontario

This division of Donlee Manufacturing Industries specializes in precision machining and assembling of long stainless steel tubes and housings, as well as related components for nuclear generating stations. The precision work includes deep hole boring, bottle boring, milling, drilling and grinding. These stainless steel tubes, which are used for housing radioactive fuel, are known as end fittings. Each fuel channel has two end fittings, one admitting heavy water coolant into the fuel chamber, allowing it to flow over the fuel and collect heat, and the other to take heavy water to a heat exchanger or boiler where it gives up heat to ordinary water to generate steam.

End fittings also house the fuel channel closure plugs which are removed to allow the fueling machine to load and unload fuel from the reactor core.

Apparently no other North American company is geared to produce end fittings.

This particular division of Donlee is equipped to handle this very special work. However, from 1963 to 1966, and again in 1970, the division had to be closed when work of this type was unattainable.

The company also specializes in the manufacture of gun barrels.

COMPANY: Canada Forgings Limited

LOCATION: P. O. Box 308
Welland, Ontario

Canada Forgings produce carbon and stainless steel forgings to nuclear codes. Typical products include end fitting forgings.

COMPANY: Standard Modern Tool Company Limited

LOCATION: 69 Montcalm Avenue
Toronto 10, Ontario

Standard Modern has developed a complete nuclear division with capability for design, manufacture, and testing. Standard Modern prepared engineering drawings for both Douglas Point and Pickering prototype fueling machines. Development and manufacture of the prototype channel closure plugs for these machines were also undertaken by its tool room.

The company has supplied equipment for Douglas Point, Rajasthan, Pickering, Gentilly, and Bruce. Included in the equipment are:

(1) Prototype fueling machine and carriage, and the fuel transfer mechanisms for Douglas Point;

(2) Fueling machines, reactivity mechanisms, booster rod drives and fuel transfer mechanisms for Rajasthan;

(3) Fueling machines, channel closure plugs and fuel transfer mechanisms for Pickering;

(4) Fueling machines for Gentilly.

Standard Modern will also manufacture the channel closure plugs, inlet and outlet shield plugs, new and special transfer mechanisms for the Bruce generating station, and upgrading the Pickering prototype fueling machine.

Standard Modern is a wholly-owned subsidiary of Staveley Industries Limited, Portland House, Stag Place, London, England.

COMPANY: Canadian General Electric Company Limited
Nuclear Energy Project

LOCATION: 107 Park Street North
Peterborough, Ontario

Canadian General Electric has been involved in the Canadian nuclear power program since the NPD station at Rolphton, Ontario. Since that time, CGE has been a participant in the Whiteshell station, Kanupp, Douglas Point, RAPP, Pickering and Gentilly. The nuclear fuel operation has supplied first fuel charges to NPD, Douglas Point, WR-1, Kanupp and Pickering, and also replacement fuel to most of the same stations. The company is also in a position to design and supply fuel manufacturing facilities, and to license customers wishing to operate such facilities.

One of the CANDU system's outstanding features is on-power fuel changing. The fuel handling systems group of CGE had complete responsibility for the systems on all the company's projects, and now has the responsibility for the design and manufacture of the fuel handling system for the Bruce generating station.

The company is almost entirely owned by its parent organization in the United States. Sales in the nuclear division have been in excess of $65.0 M (including consulting services); the total company sales have been in the order of $500.0 M.

COMPANY: Byron Jackson Division
Borg Warner (Canada) Limited

LOCATION: P. O. Box 180, Station 'H'
Toronto 13, Ontario

The Byron Jackson Division of Borg Warner has been supplying a wide range of pumps for twenty years from its plant in Scarborough. Through its parent, Byron Jackson Pump Division of Los Angeles, the company participated in a developed technology of shaft sealed nuclear pumps. The

Canadian operation has a complete engineering staff experienced in all phases of centrifugal pump design and development for both nuclear and conventional applications.

All of the CANDU-PHW stations in Canada in operation or under construction are equipped with primary coolant pumps supplied by Byron Jackson. There has, however, been a dramatic increase in pump size following the nuclear industry's philosophy for fewer but larger units. The three pumps for the 20 Mw NPD were rated at 600 Kw and handled 1,350 cu. m/h. Three years later, in 1961, Byron Jackson began work on ten heat transport pumps for Douglas Point, each rated at 900 Kw and 1,530 cu. m/h.

In 1965, Byron Jackson manufactured and tested 64 pumps for the Pickering station. These were rated at 1,420 Kw and 2,590 cu. m/h. At that time this represented the largest nuclear pump contract for any pump supplier in the world. Five years later the company began design and manufacturing of 16 giant pumps for the Bruce station. These pumps are each rated at 8,200 Kw and 11,800 cu. m/h.

Although Byron Jackson's contribution to nuclear power stations has been highlighted by the supply of heat transport pumps, the division has supplied many other pumps for each of the CANDU installations both in Canada and abroad for both nuclear and conventional thermal plant applications. For example, at Douglas Point it provided two condensate extraction pumps and three process water pumps; for Gentilly, two pumps for boiler feed, two pumps for condensate extractions and four pumps for water processing. In Pickering, Byron Jackson was also the supplier of the 20 moderator pumps, the eight primary system pressurizing pumps, 12 condensate extraction pumps, 12 boiler feed pumps, and 12 low pressure service water pumps. The big coolant pumps in Bruce will be accompanied by Byron Jackson maintenance coolant pumps (8), eight shut-down coolant pumps, and eight boiler feed pumps.

COMPANY: Bingham Pump Company Limited

LOCATION: 4129 Lozells Avenue
Burnaby 2, British Columbia

The Bingham Pump Company is the subsidiary of Bingham-Willanette Company of Portland, Oregon. The Canadian company draws upon the considerable facilities and experience of its parent company. Bingham-Willanette Company entered the nuclear pump field in 1952, supplying pumps for the pioneer Hanford atomic works. The Bingham Pump Company Limited in Burnaby engineers, designs and manufactures all types of pumps for a wide range of industrial applications, including Canada's nuclear power development program.

It has supplied stand-by and ejection pumping equipment to the reactor at Douglas Point, stand-by coolant pumps to Pickering Station, moderator pumps to the Bruce station, and primary pumps to Gentilly. In addition, Bingham supplied the Whiteshell Nuclear Research facility with primary coolant and loop testing pump equipment. Furthermore, it has been involved in many of the offshore nuclear power developments, including RAPP and Kanupp.

COMPANY: Chase Brass and Copper Company

LOCATION: Waterbury, Connecticut
U. S. A. 06720

The Zirconium Division of the Chase Metal Works plant, which produces copper alloy tubing, rod, and wire, is located in Waterbury, Connecticut. This division has been engaged in the commercial manufacture of zirconium alloy tubing since the early 1960's. Prior to that time, the development work and a few orders were done as part of Chase Brass and Copper Research and Development Department, where the basic processing techniques had been developed. The principal product has been pressure tubes as used in the CANDU design of nuclear reactors. The Zirconium Division is a very small part of the entire operation, as Chase is only a subsidiary of the Kennecott Copper Corporation.

Up to 1971, cumulative sales in this area were approximately $2.3 M.

COMPANY: Vereiniete Deutsche Metallwerke A. E.

LOCATION: Frankfurt, Germany

CANADIAN AGENTS: E. Ardo Industrial Supplies Limited (sole Canadian agents)

LOCATION: 5840 Place Plantagenet
Montreal 251, Quebec

Vereiniete Deutsche are represented in Canada by E. Ardo Inudstrail Supplies Limited. VDM manufactures its products at a special tube mill situated in Duisburg. To 1971, cumulative export sales for all nuclear power products from this tube mill had reached $7.7 M. The company produces both zircaloy tubes and NICORROF/ NICROFER tubes.

COMPANY: Pacific Tube

LOCATION: 5710 Smithway Street
Los Angeles, California
U.S.A. 90040

Pacific Tube Company is a wholly-owned subsidiary of the Superior Tube Company, a privately owned enterprise. Pacific Tube has been producing nuclear quality inconel tubing for many years, both for use in the United States naval nuclear program as well as the domestic nuclear power industry. Shipments to Ontario Hydro amounted to only $4,000.00 in 1970, but grew to $2.9 M in 1971, and was expected to increase to almost $10.0 M by 1972.

The company commenced operations in 1943 as a non-integrated re-draw mill producing seamless and welded steel tubing in various analyses. They purchased hot finished tube hollows and cooled drew them to a variety of sizes and specifications. Initially, their basic market was the aircraft, oil and chemical industries. Since then they have expanded production facilities to many additional analyses, including nickel as well as cold drawn bars. In the nuclear market, they are a supplier of tubing for heat exchangers, condensers, and moderators.

In 1966, the company commenced the construction of a specialty products mill directed toward tubing required for nuclear power industry. Here they produce nuclear alloys as well as stainless and carbon feed water tubes in extremely long lengths (up to 105 feet, either in straight or U-bends.)

COMPANY: Peacock Brothers Limited

LOCATION: P. O. Box 1040
Montreal 101, Quebec

Peacock Brothers Limited is a member of the world-wide Weir Group. The thermal power plant market, including both fossil and nuclear fueled plants, is one of the most important Canadian markets for this company. Their main interests lie in the supply of equipment for the conventional part of the power plant, including valves for steam and feed water duties, boiler feed, condensate and circulating water pumps, and the provision of support services and facilities for repair and overhaul of auxilliary machinery.

In the nuclear steam supply system they have provided valves (for the NPD project), and some pumps and specialty items such as filters and flow elements. Their future interests are related to the requirement for valves in the primary system and for supporting services in the repair and overhaul of machinery.

Peacock Brothers have received orders for main valves for the primary nuclear steam supplies system. These valves are manufactured by the principals of Peacock Brothers, Hopkinsons Limited of England, who are specialists in the design and manufacture of valves for the thermal power industry.

COMPANY: MLW Industries
MLW - Worthington Limited

LOCATION: P. O. Box 1000, Place D'Armes
Montreal 125, Quebec

MLW Industries, a division of MLW - Worthington Limited, has been operating in Montreal since 1902. MLW supplied coolers for bleed, gland and stand-by service in Douglas Point, and also provided the stand-by cooler for Pickering. At the Bruce station, MLW is supplying Ontario Hydro with moderator coolers, bleed condensers, bleed coolers, shield coolers, purification coolers, and other units. Worthington (Canada) Limited, a wholly-owned subsidiary of MLW - Worthington Limited, has two divisions with products of interest to the nuclear industry. The company manufactures pumps at Brantford, Ontario in its Masoneilan Division and is a leading supplier of valves and controllers.

COMPANY: IBM Canada Limited

LOCATION: 24 Ferrand Drive
Don Mills, Ontario

IBM Canada Limited supplied the computers required for control of the Pickering station reactors.

COMPANY: CAE Electronics Limited

LOCATION: P. O. Box 1800, St. Laurent
Montreal 379, Quebec

In addition to their general capability for supplying computer-based control systems such as that at the Bruce station, CAE has the capability in the development and manufacture of nuclear training simulators such as the one being considered for Pickering.

In 1972, CAE purchased all the outstanding shares of Welmet Industries Limited, Welland, Ontario. Welmet specializes in the production of heat and corrosion-resistant stainless steel and alloy castings. In addition, they manufacture gate, globe, check, wye and angle valves of stainless steel.

COMPANY: U. S. Steel International Limited

LOCATION: 7 King Street East
Toronto 1, Ontario

U. S. Steel is basically a supplier of raw material from which many components in the nuclear steam supply system are fabricated.

COMPANY: Canadian Westinghouse Company Limited
Atomic Power Division

LOCATION: P. O. Box 510
Hamilton, Ontario

Westinghouse Canada Limited was initially a supplier of components and systems for Canada's research reactors. Since then, the company has become a major supplier of nuclear fuel and reactor components with a world-wide reputation for dependability in engineering design, development, manufacture and testing. The company has a Port Hope plant, conveniently located near Eldorado Nuclear Limited, a major supplier of uranium oxide. The Port Hope plant supplies nuclear fuel, tubular products and reactor components. The Heavy Apparatus Divisions of Westinghouse in Hamilton are utilized for the fabrication of large reactor components and conventional equipment required for reactor installations.

Westinghouse Canada is one of the principal suppliers of power reactor fuel in Canada. Initial core loadings of natural uranium oxide power reactor fuel have been supplied for Gentilly and RAPP reactors. Natural uranium oxide re-load fuel has been supplied for Douglas Point and Pickering, and enriched re-load fuel for NPD-2. Specially designed fuel fabrication and inspection equipment has been manufactured and licensed for the use of other fuel fabricators.

Westinghouse Canada is also a major supplier of large diameter seam-welded zirconium alloy tubes employed as calandria tubes and reactivity mechanism tubes in Canadian power reactors. Tubes of this type have been supplied for Pickering, Bruce and RAPP reactors. The company's experience includes the design and manufacture of systems and components varying in size and complexity for both power and research reactors. For the Canadian power reactor program, the company has supplied the massive end shield support rings for Pickering, coolant tube spacers for Pickering and Bruce, shield plugs for Pickering and the assembly and test of closure plugs for Gentilly. A number of pressurized water, steam, and gas-cooled in-reactor test loop systems have been designed and fabricated for research reactors in Canada and the United States.

COMPANY: Wolverine Tube Division
Calumet & Hecla (Canadian) Limited

LOCATION: P. O. Box 3115
London, Ontario

Wolverine Tube believes that, with the forecast of installed nuclear power for Canada, there is a tremendous potential for growth in the allied tubular products market. These would include such things as coolant tubes, fuel cladding tubing and steam generator tubing, in alloys that they are not now capable of handling. Because of the highly specialized nature of the facility required and, at the moment, the speculative nature of the order placement, the products are now supplied from outside Canada. At the moment, no domestic manufacturing capability exists.

If the forecasts of installed capacity are reached, then there will be considerable sales in this area. However, at present most of these would go outside the country.

The company is one hundred percent Canadian controlled.

COMPANY: Canadian Ingersoll-Rand Company Limited

LOCATION: P. O. Box 610, Station 'B'
Montreal 111, Quebec

Canadian Ingersoll-Rand manufacture condensors and pumps, including pressurizing pumps, boiler feed and cooling water circulating pumps.

COMPANY: Bristol Aerospace (1968) Limited

LOCATION: P. O. Box 874
Winnipeg, Manitoba

Bristol Aerospace manufactures a variety of components for the nuclear power market. These include experimental and driver flow channels and other internal reactor components, including calandria tubes, end fittings, transition joints, pressure tubes, and general zirconium processing. To 1971, Bristol had cumulative sales in the nuclear power market of approximately $1.5 M.

COMPANY: Velan Engineering Limited

LOCATION: 2125 Ward Avenue
Montreal 378, Quebec

Velan Engineering is a Canadian company with plants in Montreal, Plattsburgh, New York, and Leicester, England. They manufacture valves of forged, carbon, alloy and stainless steel. The products include globe and check valves ranging from one-quarter inch to twenty-four inches, and 150 pounds to 2,500 pounds ANSI. Bellows seal-type valves are also available, as are gate valves, including parallel slide valves.

COMPANY: Unifin Division
Keeprite Products Limited

LOCATION: P. O. Box 2395, Terminal 'A'
London, Ontario

Unifin is a London, Ontario based division of Keeprite Products Limited, an all-Canadian company. Formed in 1920, it has been engaged in the design and manufacture of specialized heat transfer tubing and equipment for over 25 years.

Since the NPD station at Rolphton, Ontario, Unifin has been the prime supplier of sophisticated heat transfer equipment for all the Canadian-designed nuclear generating stations and research centres, including Douglas Point, Pickering, Gentilly, and Whiteshell. For example, among the many items which Unifin supplied for Pickering was 70,000 feet of steel tubing for re-heater bundles.

COMPANY: Reuter-Stokes Canada Limited

LOCATION: P. O. Box 45
Preston, Ontario

Reuter-Stokes makes self-powered flux detectors, mineral insulated cable, in-core mapping, control and safety systems, reactor instrumentation for fuel defect detection, liquid level and temperature measurements. It has a fully equipped nuclear sensor manufacturing facility, including in-house cable drawing and full nuclear quality control departments.

A large percentage of its production is for export. It has supplied, or has firm orders, for in-core flux detector systems for 17 power reactor cores, including shut-down and control systems. This includes many U.S. reactor systems. Reuter-Stokes is making an automated fuel defect monitoring system for Units Three and Four at Pickering. The detection principle is monitoring the fission products deposited on monel traps. The company has supplied equipment for monitoroing operations of emergency poison injection systems.

Reuter-Stokes Canada Limited is affiliated with Reuter-Stokes Inc. of Cleveland, Ohio, and has representatives in most other countries. Reuter-Stokes Canada makes a completely independent product line from its United States parent company; it also acts as the parent company's Canadian representative for gas-filled radiation detectors.

APPENDIX III

INTERVIEWS CONDUCTED IN PREPARATION

OF REPORT ENTITLED

"CANADA'S NUCLEAR INDUSTRY"

NAME	COMPANY	DATE
Robert Stead	Energy Board	April 11, 1974
Edward Bell	Energy Board	April 11, 1974
Reg Hayden	Public Relations AECL	April 11, 1974
W. J. Bennett	President Iron Ore Company of Canada Limited	April 28, 1974
Robert Blackburn	Atomic Energy Control Board (AECB)	April 28, 1974
Lorne McConnell	Ontario Hydro	May 8, 1974
Les Haywood	Vice-President Heavy Water Projects AECL	May 10, 1974
Joe Labinec	Commercial Products Division AECL	May 10, 1974
John Runnalls	Department of Energy, Mines and Resources	May 15, 1974
Gordon Leaist	AECL	May 22, 1974
Willis Fletcher	AECL	May 22, 1974
John Foster	Vice-President Power Program AECL	May 22, 1974
Ed DesLauriers	Treasurer AECL	May 22, 1974

NAME	COMPANY	DATE
Alex Taylor	President Canatom Limited	May 28, 1974
Chuck Hantho	Vice-President CIL	May 28, 1974
Jim Wilson	Ontario Hydro	May 29, 1974
John Matthew	Ontario Hydro	May 29, 1974

N.B. The opinions expressed in this Report are those of the people interviewed, between April 1, 1974 and May 31, 1974.