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SASK. POWER CORPORATION RECEIVED NOV 12 1993 922842 PRESIDENT'S OFFICE

November 8, 1993

Mr. Jack Messer
President and Chief Executive Officer
Saskatchewan Power Corporation
2025 Victoria Avenue
Regina, Saskatchewan
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Dear Mr. Messer,

Ernst and Young Management Consultants will be releasing the major findings of a comprehensive study of the economic effects of Canada's nuclear industry on November 9th in Toronto.

We are providing you with a copy of the highlights and the executive summary of the study.

The Ernst and Young study answers many questions about AECL and Canada's nuclear industry. You will find that Ernst and Young have made some significant discoveries: notably, the Canadian nuclear industry has contributed at least $23 billion to the Gross Domestic Product (GDP) of Canada over the past 30 years.

If you require further information, or additional copies of the executive summary, please do not hesitate to contact Chantal Cousineau of Corporate Public Affairs at (613) 237-3270.

Regards,

Bruce Howe

Bruce Howe
President and Chief Executive Officer

AECL EACL

Françoise Guenette

Vice-President
Corporate Relations

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November 8, 1993

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Vice-President, Planning
SaskPower
2025 Victoria Avenue
Regina, Saskatchewan
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Regards,

Françoise

NEWS RELEASE

November 9, 1993
Embargoed release until 11 a.m.

Canada's Nuclear Industry: First Economic Study in 15 Years Released

TORONTO – Management consultants Ernst & Young today released the results of a study of Canada's nuclear industry that documents its economic contribution of jobs, investment and technology.

The report, sponsored by Atomic Energy of Canada Limited (AECL), shows that the $4.7 billion that Canadian taxpayers have put into the nuclear industry over the past 40 years has been returned many times over.

Since commercial electricity was first generated in Canada by nuclear power in 1962, the total contribution to Gross Domestic Product (GDP) by the nuclear industry has been at least $23 billion. According to Tony Going, Principal of Ernst & Young, "The nuclear industry in Canada plays a significant role not only in the provision of electricity, but also in the creation of jobs and tax revenues for the various levels of government and contributes many other significant spin-off benefits."

Last year, $3.7 billion worth of electricity was generated by Canadian nuclear reactors, providing 15 percent of the country's supply.

Additionally, the nuclear industry directly employs 30,000 Canadians in more than 150 companies across six provinces, and 90 percent of these positions are full-time. Of these 30,000 jobs, 3,200 are engineers and scientists. Despite the recession, direct employment has increased 9 percent over the last three years. At least 10,000 more jobs in other related sectors indirectly depend on the nuclear industry.

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Between 1988 and 1992, private sector companies supplying nuclear products and services generated $9.4 billion in total sales. The sale of two CANDU reactors to South Korea was Canada's single largest export order in 1992.

John Reid, president of the Canadian Nuclear Association (CNA) said, "We knew we had a positive impact on Canada's economy. Thanks to this study, we now have a firm grasp of exactly how much. In 1992, $3.5 billion of the country's GDP came from the activities of our sector alone. That's a tremendous return in just one year on Canada's total $4.7 billion investment."

AECL has been the lead organization in the growth of the industry. The company's nuclear research, development and marketing initiatives are vital to the success of the many Canadian companies. AECL President and CEO, Bruce Howe, said, "Our partners in prosperity have shown the ability to compete successfully on the world stage. Together we have built an industry that is not only a global leader, but has enhanced the quality of life of all Canadians, every day."

- 30 -

For more information, contact: David Rowney at Ernst & Young (416) 943-3185.

"Economic Effects of the Canadian Nuclear Industry"

A Report by Ernst & Young

Highlights

- In developing Canada's nuclear energy capability, the federal government has appropriated $4.7 billion to Atomic Energy of Canada Limited since 1952.
- At least $23 billion was contributed to Canada's Gross Domestic Product (GDP) by the nuclear industry from 1962 to 1992.
- Direct employment in the nuclear industry in 1992 is estimated at about 30,000 jobs.
- Direct employment increased approximately 9% between 1989 and 1992.
- A minimum of 10,000 jobs in other sectors indirectly depend on the nuclear industry.
- Nuclear energy supplied 15% of Canada's electricity in 1992, valued at $3.7 billion.
- Private sector companies which supply nuclear products and services had total sales of $9.4 billion between 1988 and 1992.
- The federal government receives approximately $700 million annually from the nuclear industry in the form of income and sales taxes.
- Canada's nuclear industry had a trade surplus of approximately $500 million in 1991.
- Ontario Hydro estimates that, from 1965 to 1989, nuclear energy has saved the Canadian economy approximately $17 billion in foreign exchange.
- In the 1990s, foreign exchange savings will amount to approximately $1 billion a year.

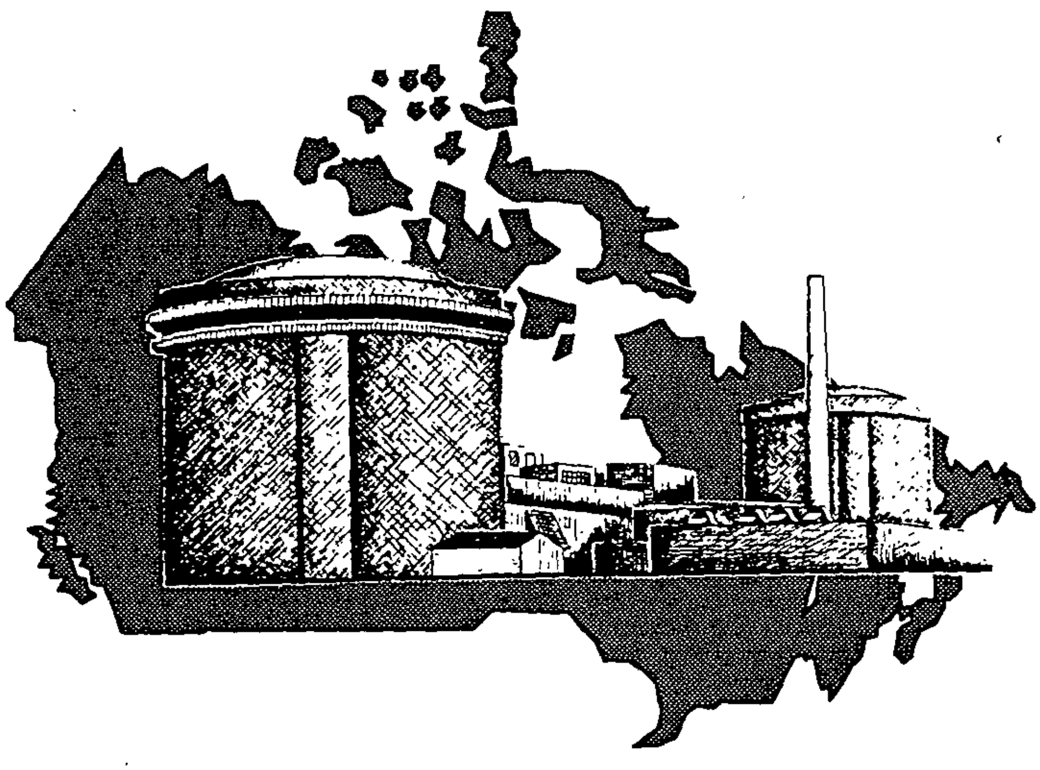
October 1993

A Report

from

Ernst & Young

*T*he *E*conomic *E*ffects of the *C*anadian *N*uclear *I*ndustry



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Key Units of Measure

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kW - Kilowatt $= 10^3$ Watts
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GW - Gigawatt $= 10^9$ Watts
TW - Terawatt $= 10^{12}$ Watts

Executive Summary

A. Study Objectives

The objective of Ernst & Young with this study was to document the economic contribution of the nuclear industry in Canada and abroad to the Canadian economy. Therefore, the major costs and benefits associated with government investment, largely federal, in the nuclear industry were documented.

In more immediate terms, another goal was to update the previous study of the effects of the Canadian nuclear industry completed by Leonard and Partners Limited in 1978.

B. Study Scope

The term "nuclear industry" was defined to include all activities directly related to the design, construction, equipment supply and operation of nuclear power facilities. This covered activities such as research and development, engineering, manufacturing, uranium mining and refining and maintenance services.

For the purposes of this study, the scope did not include activities in spin-off industries such as health sciences or agriculture that rely on nuclear technology. The only exceptions to this were Nordion International Inc. and Theratronics International Ltd., both of which were divisions of Atomic Energy of Canada Limited (AECL) until 1989. Beyond a qualitative discussion, our definition of economic effects also did not attempt to financially quantify the environmental and medical benefits from the use of nuclear technology.

We defined "government investment" as federal government expenditures on the nuclear industry including appropriations and write-offs. We recognize that this federal investment is incremental and has been leveraged by other public and private sector investments which together have resulted in the effects described in this study.

With respect to effects, both economic and non-economic effects in aggregate form, i.e., for the nation as a whole, were sought. Impacts on specific regions/ communities are presented only where such information/analysis was readily available.

C. Study Methodology

The information required to conduct this impact study was collected using the following five methods.

- Mail survey of 154 Canadian companies which supply products and/or services to the nuclear industry (a response rate of 50% was achieved),
- Interviews with 35 industry stakeholders,
- Review of 150 relevant reports and documents,
- Case studies of 5 successful companies, and
- Input-output analysis using Statistics Canada's Open Output Determination Model.

The methodology was designed to obtain the most up-to-date and reliable data directly from the primary sources. Where it was necessary to use secondary data, we have cross-checked/verified them with the primary sources to the extent possible. All sources, whether primary or secondary, have been referenced accordingly in the report. Limitations with the data have also been identified where relevant.

D. Major Findings

The major findings of our study are quantified where possible and, in our view, represent conservative, minimum estimates of effects.

Energy Supply

1. The Canadian nuclear industry plays a significant role in the provision of energy in Canada.

- Between 1962 and 1992, nuclear energy production in Canada rose from 22 GWh to 76,022 GWh (GW = Gigawatt = 10^9 watt)

- In 1992, nuclear energy supplied 15% of Canada's electricity requirements. Forty-eight percent of Ontario's electricity needs, 30% of New Brunswick's and 3% of Quebec's were met by nuclear energy last year.

- The industry produced electricity valued at $3.7 billion in 1992.

- With the completion of the Darlington station in 1993, nuclear energy provides almost 20% of Canada's electricity.

Economic Effects

2. In developing Canada's nuclear energy capability, the federal government has appropriated a net amount of $4.7 billion to AECL since 1952 in as-spent dollars. The economic effects of these appropriations are as follows:

   - ***Overall Impact on GDP***
     Using Statistics Canada's Open Output Determination Model, we conservatively estimate that the total contribution of the nuclear industry to Canada's Gross Domestic Product (GDP) from 1962 to 1992 was at least $23 billion.[1] In simple terms, over 90% of the industry inputs required to generate electricity from

[1] This contribution is based on estimates of the value of electricity generated from nuclear sources and the value of the Canadian content of exports of CANDU reactors. The first year that commercial volumes of electricity from nuclear sources were generated was 1962.

nuclear power (valued at $3.7 billion in 1992) are sourced in Canada. This means that imports constitute less than 10% of the inputs and Canadian products and services constitute over 90% of the inputs.

The GDP contribution was calculated using the value from the nuclear generation of electricity and the Canadian content of all CANDU reactors sold abroad. It does not reflect nuclear research and development activities. If these were included, the impact of the nuclear industry on Canada's GDP would be even greater.

- ***Direct Employment***
  We estimate direct employment in the nuclear industry in 1992 at about 30,000 jobs. Survey results suggest that approximately 90% of these jobs are full-time. Part-time employees work an average of 35-40% of their time on nuclear-related activities.

  Between 1989 and 1992, direct employment increased by approximately 9%. The distribution of direct employment in 1992 by area of activity is estimated as follows:

Ontario Hydro	12,000[2]
Hydro-Quebec	650
New Brunswick Power Corp.	450
AECL	4,500
Private sector suppliers	8,500
Uranium	2,200
Public sector administration	350
Construction at Darlington	870
Other	350
TOTAL	**30,000 jobs (approximately)**

Construction, refurbishing and/or maintenance activities associated with CANDU reactors are reflected in the private sector suppliers' employment numbers.

[2]The employment data do not reflect the recent layoffs at Ontario Hydro. The total impacts of these layoffs are still unknown.

- ***Indirect Employment***

  In addition to direct employment, the nuclear industry also helps support other jobs in the Canadian economy. More specifically, we conservatively estimate that a minimum of 10,000 jobs in other sectors indirectly depend on the nuclear industry. This level of indirect employment is sustained even when there are no reactors under construction at home or overseas.

  Based on analysis of the recently signed Wolsong 3 and 4 contracts, Industry and Science Canada (ISC) estimates the domestic employment multiplier to be 2.5 for the construction phase of a new export reactor project. This means that indirect employment in Canada will rise by 2,500 when each new CANDU export project is being built abroad.

  Induced employment was not calculated. Induced employment is that which is created through the spending of disposable income. However, jobs in the Canadian economy do depend on the purchases made by the employees of the nuclear industry when they spend their pay cheques.

- ***Sales***

  In 1993, Canada holds 7% of the world's market share of nuclear reactors and 10% of the market share of nuclear reactors under construction. A twin reactor order from South Korea, valued at over $1.0 billion was Canada's single largest export order in 1992.

  Based on our survey analysis, we estimate that private sector companies who supply nuclear products and services have generated total sales of $9.4 billion between 1988 and 1992. Compared to sales of $350 million in 1977, this represents a compounded growth of 23% annually. In real terms, it represents approximately a 17% compounded annual growth rate.

  At present, the split between domestic and export sales from private sector suppliers is 60%/40%. In the future, the industry expects this split to reverse. More specifically, exports are expected to account for 60% of total sales by 1998.

In addition to these private sector sales, AECL generated revenues of approximately $1.3 billion in the five years between 1988 and 1992 and $335 million in 1992. The breakdown of these revenues is as follows:

Commercial nuclear operations	= $808 million (1988-1992) = $209 million (1992)
Cost sharing and commercial R&D activities	= $484 million (1988-1992) = $126 million (1992)

- ***Tax Revenues***

  Our study estimates that the federal government receives approximately $700 million in tax revenues annually from the nuclear industry in the form of income and sales taxes This figure excludes corporate income taxes.

- ***Exports***

  Annual exports of nuclear products and services in 1991 were approximately $550 million. This comprised:

  - Uranium exports = $290 million
  - AECL exports = $100 million
  - Other exports (i.e. Theratronics) = $100 million
  - Nuclear electricity exports by the utilities = $61 million

  With respect to CANDU project sales, the confirmed sale of two additional CANDU 6 reactors to South Korea is expected to result in more than $1.5 billion in new business in Canada during the construction lifetime of the entire 4-unit Wolsong project (1976 to 1999). Ninety percent of the products and services for these exports to South Korea will be sourced in Canada (excluding construction).

- ***Positive Trade Balance***

  Canada's nuclear industry has a positive trade balance given its significant exports and limited imports. Specifically, the nuclear industry imports approximately $50 million worth of specialized equipment each year and special metals and alloys like zirconium for use as fuel bundle cladding or sheathing materials.

Estimates of the size of the positive trade balance vary. Using the figures referred to above and subtracting imports of approximately $50 million, our study estimates that the nuclear industry in 1991 generated a positive trade balance of $500 million.

Based on its definition of the high technology components of the nuclear industry, Industry and Science Canada estimated that the nuclear industry generated a trade surplus of $250 million in 1991. In fact, by ISC calculation, nuclear and aerospace were the only two Canadian industries in the high technology area with surplus trade balances. All other high technology areas including telecommunication and biotechnology had trade deficits.

Industry	$millions
Aerospace	$950
Nuclear	**$250**
Biotechnology	($60)
Opto-electronics	($190)
Weapons	($280)
Material Design	($500)
Computers and Telecommunications	($3800)
Computer Integrated Manufacturing	($1300)
Electronics	($1500)
Life Sciences	($1900)

Source: Industry and Science Canada, 1992

However, among the exports defined as high-tech is natural uranium oxide, which has the lion's share (98%) of the nuclear positive trade balance. The remainder consists of nuclear reactors, or parts of, and instrumentation, fuel elements and other special uranium compounds.

- ***Foreign Exchange Savings or Positive Contribution to the Current Account Deficit***

  Ontario Hydro estimates that, from 1965 to 1989, nuclear energy has saved the Canadian economy approximately $17 billion (1989 dollars) in foreign exchange. In the absence of nuclear energy, this money would have been spent on importing coal from the United States to Ontario and importing oil or coal into

Quebec and the Atlantic provinces. Ontario Hydro estimates that, in the 1990s, foreign exchange savings will amount to approximately $1 billion a year.

- ***Regional Development***

The nuclear industry is dynamic and opportunities for private companies emerge in cycles depending on whether new CANDU reactors are being constructed. For this reason, the number of companies vary from year to year. In 1992, we estimate that there were 154 Canadian companies that supplied manufactured or engineered products and/or services to AECL and the electric power generating utilities.

Fifty-eight percent of the companies we identified are based in Ontario, 14% in Alberta and 12% in Quebec. Companies located in Alberta are mainly small suppliers who provide products and services to the uranium industry. The remaining provinces have 16% of the private-sector suppliers. Sixty-six percent of these companies are in manufacturing, 30% in engineering and design, and 16% in R&D.

Survey results reveal that one quarter of these companies are new entrants to the nuclear industry, i.e., they started supplying nuclear products and services in the last ten years. In terms of percentage growth, New Brunswick has seen a doubling of suppliers since 1978 (albeit from a small base), Quebec has seen a 22% growth, Ontario has seen an 18% growth, and Alberta has seen a 14% growth.

Spin-Off Benefits

3. In addition to the economic benefits identified above, the nuclear industry has realized several "spin-off" benefits that have created new industries and domestic and export markets for Canada in the following three major areas: medical sciences, environment and agriculture.

For example, Theratronics (formerly the Medical Products Division of AECL) has built over 1,300 of the world's cobalt therapy machines. Every year, an estimated one-half million people are treated for cancer, in 70 countries, using these machines.

Nordion, also a former division of AECL, is the world's leading supplier of Cobalt-60 irradiation facilities used in the sterilization of medical and surgical equipment. Nordion supplies and markets most of the radioisotopes used in medical diagnosis. About 7 million people benefit from these isotopes every year.

Irradiation is also used to sterilize insects, to improve the nutritional characteristics of feed livestock and to gauge optimal hormone levels and breeding times. The combined result is more productive and disease-resistant livestock.

In terms of environmental benefits, nuclear energy is a clean form of energy, particularly in comparison to fossil sources such as coal and oil. Because there is no combustion during the nuclear reaction, nuclear energy does not emit acid gases or carbon dioxide (CO_2). This helps avert acid rain and reduces global warming (the "greenhouse effect").

In addition, the demanding quality assurance processes developed in and for the nuclear industry have had a very broad and beneficial impact in many sectors.

Enhanced Competitiveness

4. According to the Canadian companies surveyed, participation in the nuclear industry has helped enhance their competitiveness in the following ways.

- it has helped improve the quality of products and services for 33% of supplier companies surveyed,
- it has facilitated increased access to foreign nuclear markets for 22%,
- it has facilitated increased access to new markets in non-nuclear areas for 20% of companies, and
- it has improved the safety standards of 12% of the companies surveyed.

E. Summary of Benefits

In summary, government appropriations for AECL were $167 million in 1992. This investment levered other public and private sector investments which together resulted in the following economic effects:

- Produced energy valued at $3.7 billion in 1992
- Directly employed 30,000 people in 1992
- Created indirect employment of at least 10,000 in 1992
- Generated federal tax revenues of $700 million in 1992
- Generated nuclear trade surplus of $500 million in 1991
- Generated revenues of $335 million for AECL from commercial nuclear operations and R&D activities in 1992
- Resulted in foreign exchange savings of approximately $1 billion in 1992

F. Conclusions

We conclude that the economic effects of the Canadian nuclear industry have been substantial. Over the past 31 years, the GDP contributions of the nuclear power generation industry has been at least $23 billion (as-spent dollars). The GDP contributions for 1992 were $3.5 billion.

The nuclear industry also supports at least 40,000 direct and indirect Canadian jobs associated with both nuclear research and CANDU technology.

Spin-off benefits from the nuclear industry have augmented Canadian technological and commercial capabilities in other sectors such as agriculture, medicine and the environment. For example, commercial operations such as Theratronics are directly linked to the government's decision to appropriate funds for the development of nuclear applications.

Increased quality standards for Canadian manufacturing companies are a result of the stringent standard demanded for goods produced for nuclear application. Such standards have allowed companies supplying the industry to gain a competitive advantage in technical design and engineering.

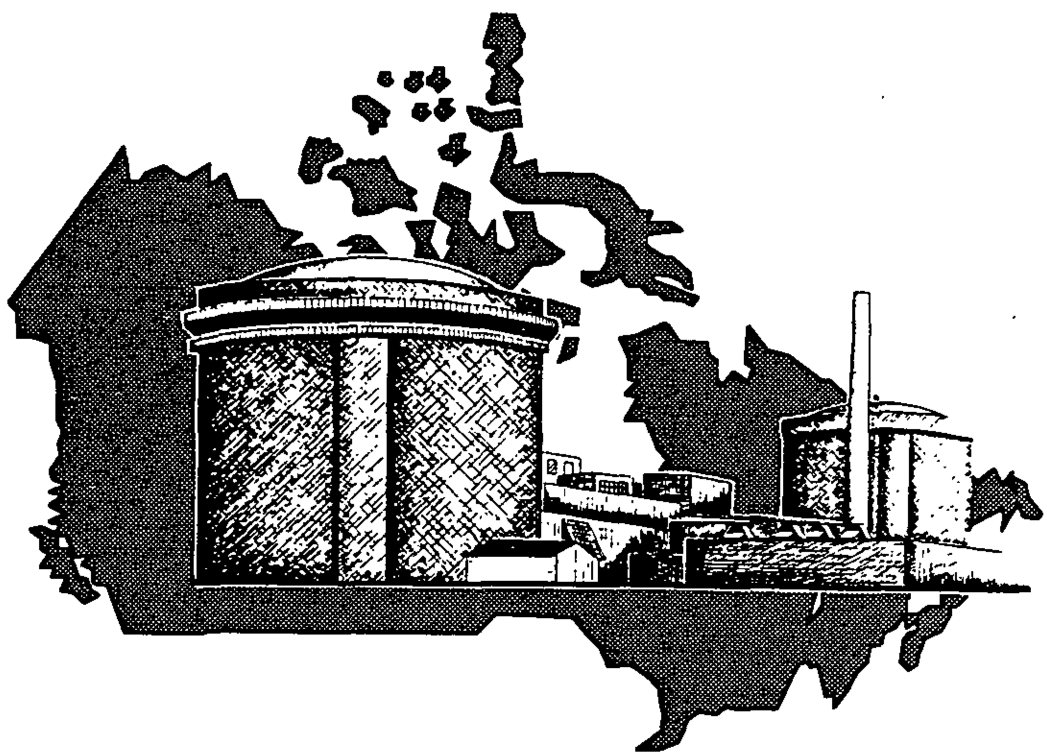
Until recently, AECL had focused primarily on enhancing the capacity of the domestic market. At the present, nuclear power is supplying close to 20% of Canada's electricity needs. However, there are no concrete plans for developing new nuclear generating plants in Canada and, with the temporary decline for new domestic nuclear capacity, the industry is pursuing export opportunities. This strategy has been successful as seen by the recent signing of the Wolsong 3 and 4 contracts with South Korea.

Based on our study, we conclude that the Canadian nuclear industry has the capability to sustain current levels of economic activity through export projects assuming the current base of 22 nuclear reactors in Canada is maintained. Our findings indicate that there is an excess of electricity on the national market at present. However, assuming that this situation will transform into a long term trend is ill-advised. Long term predictions show electricity needs will increase as the Canadian economy either stabilizes or grows. Since nuclear is an important component in Canada's electricity mix, substitution by an alternative fuel type would be costly in both economic and environmental terms.

In 1992, the nuclear industry had a positive trade balance of $250 million, one of the two industries within the high technology sector to do so. The industry must continue to find new opportunities abroad to maintain the technological advances and ensure qualified human resources remain trained in the nuclear field. This will help maintain Canada's nuclear capability for future use when domestic demand for nuclear energy strengthens. Future nuclear exports will help safeguard Canada's investment in the nuclear industry and will maintain nuclear as a viable energy option.

October 1993

*T*he *E*conomic *E*ffects of the *C*anadian *N*uclear *I*ndustry



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Key Units of Measure

Power:

Power is the rate of expending energy and is measured in Watts (W) as follows:

kW	- Kilowatt	$= 10^3$	Watts
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D. Major Findings

The major findings of our study are quantified where possible and, in our view, represent conservative, minimum estimates of effects. All calculations are shown in Section Three beginning on page 46.

Energy Supply

1. The Canadian nuclear industry plays a significant role in the provision of energy in Canada.

- Between 1962 and 1992, nuclear energy production in Canada rose from 22 GWh to 76,022 GWh (GW = Gigawatt = 10^9 watt)

- In 1992, nuclear energy supplied 15% of Canada's electricity requirements. Forty-eight percent of Ontario's electricity needs, 30% of New Brunswick's and 3% of Quebec's were met by nuclear energy last year.

- The industry produced electricity valued at $3.7 billion in 1992.

- With the completion of the Darlington station in 1993, nuclear energy provides almost 20% of Canada's electricity.

Economic Effects

2. In developing Canada's nuclear energy capability, the federal government has appropriated a net amount of $4.7 billion to AECL since 1952 in as-spent dollars. The economic effects of these appropriations are as follows:

   - ***Overall Impact on GDP***
     Using Statistics Canada's Open Output Determination Model, we conservatively estimate that the total contribution of the nuclear industry to Canada's Gross Domestic Product (GDP) from 1962 to 1992 was at least $23 billion.[1] In simple

[1]This contribution is based on estimates of the value of electricity generated from nuclear sources and the value of the Canadian content of exports of CANDU reactors. The first year that commercial volumes of electricity from nuclear sources were generated was 1962.

terms, over 90% of the industry inputs required to generate electricity from nuclear power (valued at $3.7 billion in 1992) are sourced in Canada. This means that imports constitute less than 10% of the inputs and Canadian products and services constitute over 90% of the inputs.

The GDP contribution was calculated using the value from the nuclear generation of electricity and the Canadian content of all CANDU reactors sold abroad. It does not reflect nuclear research and development activities. If these were included, the impact of the nuclear industry on Canada's GDP would be even greater.

- ***Direct Employment***

  We estimate direct employment in the nuclear industry in 1992 at about 30,000 jobs. Survey results suggest that approximately 90% of these jobs are full-time. Part-time employees work an average of 35-40% of their time on nuclear-related activities.

  Between 1989 and 1992, direct employment increased by approximately 9%. The distribution of direct employment in 1992 by area of activity is estimated as follows:

Ontario Hydro	12,000[2]
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AECL	4,500
Private sector suppliers	8,500
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Public sector administration	350
Construction at Darlington	870
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TOTAL	**30,000 jobs (approximately)**

Construction, refurbishing and/or maintenance activities associated with CANDU reactors are reflected in the private sector suppliers' employment numbers.

[2]The employment data do not reflect the recent layoffs at Ontario Hydro. The total impacts of these layoffs are still unknown.

- ***Indirect Employment***

  In addition to direct employment, the nuclear industry also helps support other jobs in the Canadian economy. More specifically, we conservatively estimate that a minimum of 10,000 jobs in other sectors indirectly depend on the nuclear industry. This level of indirect employment is sustained even when there are no reactors under construction at home or overseas.

  Based on analysis of the recently signed Wolsong 3 and 4 contracts, Industry and Science Canada (ISC) estimates the domestic employment multiplier to be 2.5 for the construction phase of a new export reactor project. This means that indirect employment in Canada will rise by 2,500 when each new CANDU export project is being built abroad.

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- ***Sales***

  In 1993, Canada holds 7% of the world's market share of nuclear reactors and 10% of the market share of nuclear reactors under construction. A twin reactor order from South Korea, valued at over $1.0 billion was Canada's single largest export order in 1992.

  Based on our survey analysis, we estimate that private sector companies who supply nuclear products and services have generated total sales of $9.4 billion between 1988 and 1992. Compared to sales of $350 million in 1977, this represents a compounded growth of 23% annually. In real terms, it represents approximately a 17% compounded annual growth rate.

  At present, the split between domestic and export sales from private sector suppliers is 60%/40%. In the future, the industry expects this split to reverse. More specifically, exports are expected to account for 60% of total sales by 1998.

In addition to these private sector sales, AECL generated revenues of approximately $1.3 billion in the five years between 1988 and 1992 and $335 million in 1992. The breakdown of these revenues is as follows:

Commercial nuclear operations	= $808 million (1988-1992) = $209 million (1992)
Cost sharing and commercial R&D activities	= $484 million (1988-1992) = $126 million (1992)

- ***Tax Revenues***
  Our study estimates that the federal government receives approximately $700 million in tax revenues annually from the nuclear industry in the form of income and sales taxes. This figure excludes corporate income taxes.

- ***Exports***
  Annual exports of nuclear products and services in 1991 were approximately $550 million. This comprised:

  - Uranium exports = $290 million
  - AECL exports = $100 million
  - Other exports (i.e. Theratronics) = $100 million
  - Nuclear electricity exports by the utilities = $61 million

  With respect to CANDU project sales, the confirmed sale of two additional CANDU 6 reactors to South Korea is expected to result in more than $1.5 billion in new business in Canada during the construction lifetime of the entire 4-unit Wolsong project (1976 to 1999). Ninety percent of the products and services for these exports to South Korea will be sourced in Canada (excluding construction).

- ***Positive Trade Balance***
  Canada's nuclear industry has a positive trade balance given its significant exports and limited imports. Specifically, the nuclear industry imports approximately $50 million worth of specialized equipment each year and special

metals and alloys like zirconium for use as fuel bundle cladding or sheathing materials.

Estimates of the size of the positive trade balance vary. Using the figures referred to above and subtracting imports of approximately $50 million, our study estimates that the nuclear industry in 1991 generated a positive trade balance of $500 million.

Based on its definition of the high technology components of the nuclear industry, Industry and Science Canada estimated that the nuclear industry generated a trade surplus of $250 million in 1991. In fact, by ISC calculation, nuclear and aerospace were the only two Canadian industries in the high technology area with surplus trade balances. All other high technology areas including telecommunication and biotechnology had trade deficits.

Industry	**$millions**
Aerospace	$950
Nuclear	**$250**
Biotechnology	($60)
Opto-electronics	($190)
Weapons	($280)
Material Design	($500)
Computers and Telecommunications	($3800)
Computer Integrated Manufacturing	($1300)
Electronics	($1500)
Life Sciences	($1900)

Source: Industry and Science Canada, 1992

However, among the exports defined as high-tech is natural uranium oxide, which has the lion's share (98%) of the nuclear positive trade balance. The remainder consists of nuclear reactors, or parts of, and instrumentation, fuel elements and other special uranium compounds.

- ***Foreign Exchange Savings or Positive Contribution to the Current Account Deficit***

  Ontario Hydro estimates that, from 1965 to 1989, nuclear energy has saved the Canadian economy approximately $17 billion (1989 dollars) in foreign exchange. In the absence of nuclear energy, this money would have been spent on importing coal from the United States to Ontario and importing oil or coal into

Quebec and the Atlantic provinces. Ontario Hydro estimates that, in the 1990s, foreign exchange savings will amount to approximately $1 billion a year.

- ***Regional Development***

  The nuclear industry is dynamic and opportunities for private companies emerge in cycles depending on whether new CANDU reactors are being constructed. For this reason, the number of companies vary from year to year. In 1992, we estimate that there were 154 Canadian companies that supplied manufactured or engineered products and/or services to AECL and the electric power generating utilities.

  Fifty-eight percent of the companies we identified are based in Ontario, 14% in Alberta and 12% in Quebec. Companies located in Alberta are mainly small suppliers who provide products and services to the uranium industry. The remaining provinces have 16% of the private-sector suppliers. Sixty-six percent of these companies are in manufacturing, 30% in engineering and design, and 16% in R&D.

  Survey results reveal that one quarter of these companies are new entrants to the nuclear industry, i.e., they started supplying nuclear products and services in the last ten years. In terms of percentage growth, New Brunswick has seen a doubling of suppliers since 1978 (albeit from a small base), Quebec has seen a 22% growth, Ontario has seen an 18% growth, and Alberta has seen a 14% growth.

Spin-Off Benefits

3. In addition to the economic benefits identified above, the nuclear industry has realized several "spin-off" benefits that have created new industries and domestic and export markets for Canada in the following three major areas: medical sciences, environment and agriculture.

For example, Theratronics (formerly the Medical Products Division of AECL) has built over 1,300 of the world's cobalt therapy machines. Every year, an estimated one-half million people are treated for cancer, in 70 countries, using these machines.

Nordion, also a former division of AECL, is the world's leading supplier of Cobalt-60 irradiation facilities used in the sterilization of medical and surgical equipment. Nordion supplies and markets most of the radioisotopes used in medical diagnosis. About 7 million people benefit from these isotopes every year.

Irradiation is also used to sterilize insects, to improve the nutritional characteristics of feed livestock and to gauge optimal hormone levels and breeding times. The combined result is more productive and disease-resistant livestock.

In terms of environmental benefits, nuclear energy is a clean form of energy, particularly in comparison to fossil sources such as coal and oil. Because there is no combustion during the nuclear reaction, nuclear energy does not emit acid gases or carbon dioxide (CO_2). This helps avert acid rain and reduces global warming (the "greenhouse effect").

In addition, the demanding quality assurance processes developed in and for the nuclear industry have had a very broad and beneficial impact in many sectors.

Enhanced Competitiveness

4. According to the Canadian companies surveyed, participation in the nuclear industry has helped enhance their competitiveness in the following ways.

- it has helped improve the quality of products and services for 33% of supplier companies surveyed,
- it has facilitated increased access to foreign nuclear markets for 22%,
- it has facilitated increased access to new markets in non-nuclear areas for 20% of companies, and
- it has improved the safety standards of 12% of the companies surveyed.

E. Summary of Benefits

In summary, government appropriations for AECL were $167 million in 1992. This investment levered other public and private sector investments which together resulted in the following economic effects:

- Produced energy valued at $3.7 billion in 1992
- Directly employed 30,000 people in 1992
- Created indirect employment of at least 10,000 in 1992
- Generated federal tax revenues of $700 million in 1992
- Generated nuclear trade surplus of $500 million in 1991
- Generated revenues of $335 million for AECL from commercial nuclear operations and R&D activities in 1992
- Resulted in foreign exchange savings of approximately $1 billion in 1992

F. Conclusions

We conclude that the economic effects of the Canadian nuclear industry have been substantial. Over the past 31 years, the GDP contributions of the nuclear power generation industry has been at least $23 billion (as-spent dollars). The GDP contributions for 1992 were $3.5 billion.

The nuclear industry also supports at least 40,000 direct and indirect Canadian jobs associated with both nuclear research and CANDU technology.

Spin-off benefits from the nuclear industry have augmented Canadian technological and commercial capabilities in other sectors such as agriculture, medicine and the environment. For example, commercial operations such as Theratronics are directly linked to the government's decision to appropriate funds for the development of nuclear applications.

Increased quality standards for Canadian manufacturing companies are a result of the stringent standard demanded for goods produced for nuclear application. Such standards have allowed companies supplying the industry to gain a competitive advantage in technical design and engineering.

Until recently, AECL had focused primarily on enhancing the capacity of the domestic market. At the present, nuclear power is supplying close to 20% of Canada's electricity needs. However, there are no concrete plans for developing new nuclear generating plants in Canada and, with the temporary decline for new domestic nuclear capacity, the industry is pursuing export opportunities. This strategy has been successful as seen by the recent signing of the Wolsong 3 and 4 contracts with South Korea.

Based on our study, we conclude that the Canadian nuclear industry has the capability to sustain current levels of economic activity through export projects assuming the current base of 22 nuclear reactors in Canada is maintained. Our findings indicate that there is an excess of electricity on the national market at present. However, assuming that this situation will transform into a long term trend is ill-advised. Long term predictions show electricity needs will increase as the Canadian economy either stabilizes or grows. Since nuclear is an important component in Canada's electricity mix, substitution by an alternative fuel type would be costly in both economic and environmental terms.

In 1992, the nuclear industry had a positive trade balance of $250 million, one of the two industries within the high technology sector to do so. The industry must continue to find new opportunities abroad to maintain the technological advances and ensure qualified human resources remain trained in the nuclear field. This will help maintain Canada's nuclear capability for future use when domestic demand for nuclear energy strengthens. Future nuclear exports will help safeguard Canada's investment in the nuclear industry and will maintain nuclear as a viable energy option.

Section One: Introduction

1.1 Study Context

The Need for Energy

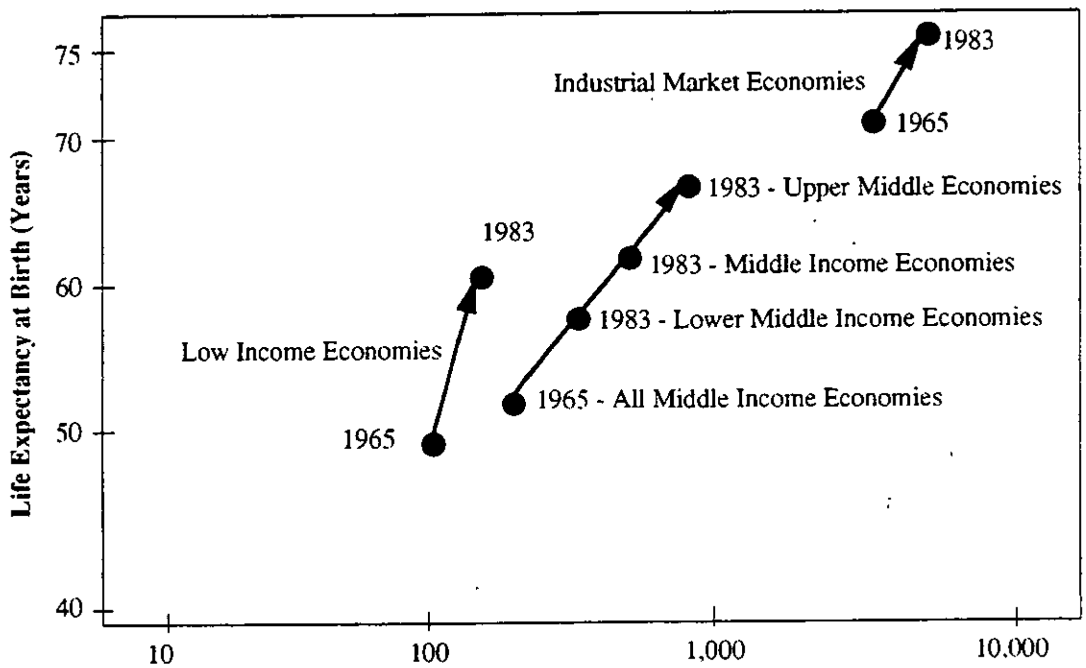
Energy is an all pervasive factor of our daily lives. In our manufacturing industries, energy is an essential ingredient to operating our factories and is a key input for producing thousands of consumer products that enhance the quality of our lives. At the consumer level, energy heats and lights homes, powers televisions, and cooks food. For social services, energy is required to power hospitals. Advanced societies prosper to the extent that they have access to adequate supplies of energy.

Exhibit 1.1 supports this point. Life expectancy is shortened in economies with low energy consumption. Among low-income economies, an increase in life expectancy from 50 to 60 years (achieved during the 1965 to 1983 period) was accompanied by a doubling of per capita energy consumption. The transformation of the average life expectancy in industrial economies from 70 years (1965) to 75 years (1983) was also accompanied by a substantial increase in the per capita consumption of energy. This pattern of linkage between life expectancy and per capita energy consumption is evident in all societies.

Exhibit 1.2 illustrates the changes in electricity and energy consumption in relation to Gross Domestic Product (GDP). As shown, the growth rates in GDP and electricity generally remain in step even when the growth rates in total energy consumption show declining trends. Simply put, electricity continues to maintain a preferred niche in the energy supply mix for all the industrialized countries. This is true for the developing nations as well. The ability to convert electricity into other energy forms, the ease of controlled distribution and the capacity for concentration make electricity the preferred form of energy.

The simple conclusion to be drawn is that nations must have a dependable supply of electricity if they are to provide their citizens with a high quality of life and if they are to remain competitive in industrial and economic facets. It is for this reason that security of energy supply is a key national priority among nations of the world.

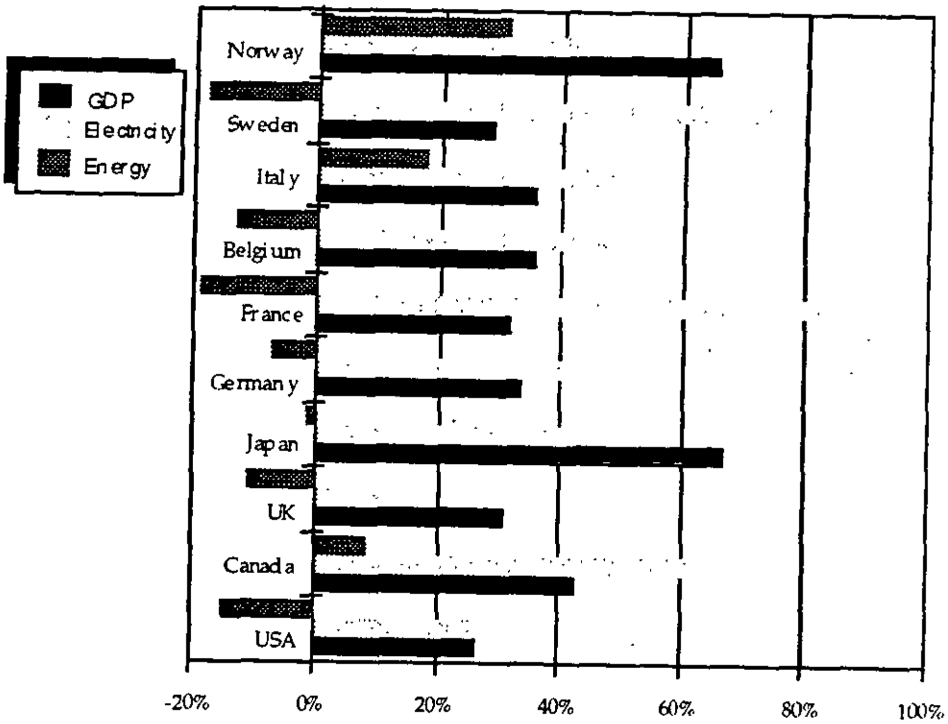
Exhibit 1.1: Energy Consumption and Life Expectancy for Different Economies (1965 - 1983)



Source: Energy for 300 years, Institute for Risk Research, 1992

Exhibit 1.2: Changes in Energy & Electricity Consumption in Relation to GDP, (1973 - 1988)

	GDP	*Electricity*	*Energy*
USA	27%	26%	-15%
Canada	43%	61%	9%
UK	31%	12%	-11%
Japan	67%	42%	-1%
Germany	34%	42%	-7%
France	32%	85%	-19%
Belgium	36%	52%	-13%
Italy	36%	52%	18%
Sweden	29%	78%	-18%
Norway	66%	44%	31%



Source: Energy for 300 Years, Institute for Risk Research, 1992

1.2 Federal Government Appropriation in Nuclear and Other Energy Sectors

As shown in Exhibit 1.3, gross government appropriations in support of the nuclear industry in Canada were $3.9 billion from 1978 to 1992 in as-spent dollars. Taking into consideration revenues flowing to the government from such sources as the privatization of certain former AECL operations, net appropriations were $3.3 billion. That is, government investment in and through AECL has been levered to develop an entire industry. Net appropriations to AECL represent 11% of the total federal government appropriations in the energy field ($30.8 billion) during this period. This does not take into consideration government expenditures in the areas of energy renewables or energy efficiency.

It should be kept in mind that the expenditure figures reported in the Government Public Accounts and those documented in AECL Annual Reports differ because the Public Accounts provide gross expenditures only and do not reflect revenues received from AECL.

Nor do our estimates of investment match those of previous studies, notably the "Sparrow" or the Tenth Report of the Standing Committee on Energy, Mines and Resources from 1988. We believe this is mainly attributable to the calculation of net, not gross, investment and definitions of what investment is considered the seed-money of the Canadian nuclear industry.

For example, unlike the 1988 reports we have not included uranium investments in the cost of developing and refining the nuclear option. Additionally, Ontario Hydro has invested approximately $28 billion in nuclear plant and support infrastructure in the province[1]. It is our assessment that these costs have been reflected in the pricing of electricity to Ontario Hydro's customers.

[1] Ontario Hydro and the Changing World of Nuclear Products and Services, Speech to the CNA, February 9, 1993

Exhibit 1.3 - Total Cost of Programs From the Years 1978-1992 (As-spent Dollars)

	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	TOTAL
Energy																
Operating	**	**	**	**	**	**	**	$113,168,738	$115,609,058	$110,275,381	$103,032,984	$101,826,789	$425,857,009	$439,656,160 0	419,534,156	
capital								$1,318,187	$1,359,461	$1,464,230	$3,201,678	$8,023,913	$49,282,849	$44,308,834 0	45,878,380	
Transfer								$3,682,901,202	$1,751,233,633	$1,046,004,226	$548,679,905	$685,845,392	$374,898,975	$347,102,577 0	226,033,414	
SUB TOTAL	$1,193,664,000	$643,637,000	$1,701,720,000	$3,201,569,000	$3,541,826,000	$2,661,471,000	$2,586,785,000	$3,797,388,327	$1,868,202,152	$1,157,743,837	$654,914,567	$795,696,094	$850,038,833	$831,067,571.0	691,354,950	$26,177,078,331.0
AECB																
Operating	**	**	**	**	**	**	**	$19,787,873	$19,874,005	$21,182,373	$21,906,000	$23,528,027	$26,080,872	$31,698,984 0	34,271,144	
capital								$221,453	$257,911	$542,090	$503,732	$824,721	$2,304,287	$2,521,346 0	2,115,101	
Transfer								$443,630	$592,600	$569,500	$466,800	$450,890	$157,000	$589,019 0	795,108	
SUB TOTAL	$12,145,000	$13,803,000	$13,144,000	$13,203,000	$16,134,000	$15,973,000	$19,903,000	$20,452,956	$20,724,516	$22,293,963	$22,876,532	$24,803,638	$28,542,159	$34,809,349.0	37,181,353	$315,989,466.0
AECL																
Operating	**	**	**	**	**	**	**	$325,535,698	$244,892,753	$199,689,283	*	*	*	*		
capital									$30,228,000	$17,892,000						
Transfer																
SUB TOTAL	$216,062,000	$119,120,000	$123,449,000	$841,567,000[1]	$283,935,000	$315,193,000	$336,317,000	$325,535,698	$275,120,753	$217,581,283	$175,409,618	$203,077,185	$205,640,000	$167,456,000.0	175,973,000	$3,981,436,537.0
NEB																
Operating	**	**	**	**	**	**	**	$23,796,944	$24,727,294	$24,768,456	$25,077,111	$22,133,086	$22,875,908	$23,098,671 0	36,016,517	
capital								$246,035	$328,020	$796,779	$541,064	$438,777	$704,784	$530,555 0	1,065,733	
Transfer																
SUB TOTAL	$11,872,000	$11,961,000	$13,482,000	$14,776,000	$17,639,000	$20,692,000	$24,092,000	$24,042,979	$25,055,314	$25,565,235	$25,618,175	$22,571,863	$23,580,692	$23,629,226.0	37,082,250	$321,659,734.0
GRAND TOTAL	$1,433,743,000	$788,521,000	$1,851,795,000	$4,071,115,000	$3,859,534,000	$3,013,329,000	$2,967,097,000	$4,167,419,960	$2,189,102,735	$1,423,184,318	$878,818,892	$1,046,148,780	$1,107,801,684	$1,056,962,146	$946,591,553	$30,796,164,068

All information from Public Accounts, 1978-1992

* Breakdown not published

** The information contained in the breakdown for these years is not consistent with that of subsequent years

Energy includes the following
Admin. of Frontier Oil & Gas Lands
Mineral & Metal Policy
Mineral & Energy Tech
Geological Surveys
Administration

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Exhibit 1.4 - Federal Government Funding to Various Energy Development (1978) in million of dollars

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	TOTAL
Energy Contributions	979.6	690.5	1,674.6	4,320.2	3,838.0	5,273.1	4,368.4	5,869.6	2,844.6	1,054.9	602.1	685.8	247.0	248.0	198.5	32,894.9
POCI	-	-	-	-	-	1,808.9	1,729.0	1,735.3	1,499.8	948.4	154.5	-	-	-	-	7,875.9
Oil Import Compensation	-	-	1,632.9	3,161.7	3,456.4	-	2,232.9	3,454.8	957.3	83.1	-	-	-	-	-	14,979.1
Compensation Revolving Fund	-	-	-	905.1	-	-	-	-	-	-	-	-	-	-	-	905.1
Interprovincial Pipeline	-	-	-	-	-	970.4	-	-	-	-	-	-	-	8.3	10.6	989.3
CEDIP	-	-	-	-	-	-	-	-	-	-	350.0	602.1	155.7	-	-	1,107.8
Exploration Incentive Program	-	-	-	-	-	-	-	-	-	-	-	-	44.3	-	-	44.3
Hibernia	-	-	-	-	-	-	-	-	-	-	-	-	-	30.9	106.4	137.3
OSLO	-	-	-	-	-	-	-	-	-	-	-	-	-	35.4	5.6	41
Vancouver Pipeline	-	-	-	-	-	-	-	-	-	-	-	-	-	137.7	12.3	150
COSP	-	-	-	138.3	224.5	190.1	185.8	112.1	-	-	-	-	-	-	-	850.8
Energy Grants	11.6	11.4	24.8	24.5	24.3	0.2	0.2	21.2	5.03	0.2	0.2	0.4	0.2	0.2	0.2	124.63
Oil & Gas Lands	0.6	0.6	0.7	0.7	-	-	-	0.2	81.3	22.9	51.3	48.7	29.7	-	-	236.7
N.S. Infrastructure Cost	-	-	-	-	-	-	-	0.02	80.7	-	31.0	28.6	8.3	2.8	2.7	154.12
NFLD Infrastructure Cost	-	-	-	-	-	-	-	-	0.6	18.6	18.1	17.3	10.6	23.9	39.7	128.8
Contribution to Nfld/Can	-	-	-	-	-	-	-	-	-	2.2	2.2	2.8	2.4	2.4	2.4	14.4
Payments to N.S Resource Ltd	-	-	-	-	-	-	-	-	-	-	25.0	-	8.03	-	12.6	45.63
Mineral & Metal Policy	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Exploration Incentive Program	-	-	-	-	-	-	-	-	-	-	-	-	101.3	79.9	9.8	191
Mineral & Energy Technology	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
AOSTRA	-	-	-	-	-	-	-	-	0.4	0.4	1.0	0.9	1.4	.27	.23	4.5
AECL	216	119	123	842	284	315	336	326	275	218	175	203	205	167	175	3,979

Notes, Explanations and Abbreviations:

- Years indicated are federal government fiscal years. For example, 1979 refers to the 1978/79 fiscal year.
- POCI - Petroleum Ownership, Control and Incentives - Incentive Programs existing during the years 83-89 (mainly the Petroleum Incentive Program)
- Oil Import Compensation - Compensation payments to refineries and other importers of crude oil and petroleum products.
- Compensation Revolving Fund - Compensation payable to first users of designated classes of high-cost domestic petroleum to bring price obtained for such petroleum to international crude price levels.
- Interprovincial Pipeline - Payments to Interprovincial Pipe line Company in respect of defincies incurred by the Company in connection with the construction and operation of the Interprovincial Pipe Line.
- CEDIP - Canadian Exploration and Development Incentive Program
- Vancouver Pipeline - In support of the Vancouver Island Pipe Line Project a natural gas pipeline joining Vancouver Island to mainland B.C.
- Nova Scotia Infrastructure Cost - In support of infrastructure costs directly or indirectly relating to the exploration for and development, production or transportation of oil and gas in the offshore area of Nova Scotia.
- Newfoundland Infrastructure Cost - In support of infrastructure costs directly or indirectly relating to the exporation for and development, production or transportation of oil and gas in the offshore area of Newfoundland.
- Contribution to Newfoundland Canada - Contribution to the Canada/Newfoundland Offshore Petroleum Board.
- Payments to N.S - Resources - Payments to Nova Scotia Resources Limited in respect of Canadian exploration expenses and Canadian development expenses.
- AOSTRA - Alberta Oil Sands Technology and Research Authority. Plays a major role in developing new technology for the recovery and processing of petroleum from the Alberta oil sands.
- AECL - These figures denotes total spending by EMR on AECL. As a separate crown corporation, AECL's operating expenditures are thus covered from this amount. For most of the other energy activities indicated above, internal bureaucracies were formed.

As illustrated in Exhibit 1.4, government funding to nuclear was significantly lower than the Oil Import Compensation (OIC) program which received $15 billion and the Petroleum Ownership, Control and Incentives (POCI) program which received $7.9 billion. This finding stands even when one considers that some of this fossil fuel sector support was offset through the introduction of the petroleum and gas revenue tax.

Nuclear Energy in Canada

Canada has an extensive history in the nuclear energy field. The development for commercial purposes dates to the early 1950s when the federal government made the decision to invest in the nuclear option as a means of securing a future supply of energy. Since then, the premises upon which Canadian energy policies were built have shifted - perhaps permanently. Security of supply was a consideration of great weight, particularly in the wake of the Organization of Petroleum Exporting Countries' oil embargo of 1973.

> Since 1973, crude oil has followed an evolutionary pattern from one of the most plentiful and cheap of energy commodities to one of the most scarce and dear, only recently reverting back to a comparatively inexpensive energy form traded in conditions of considerable over-supply. The price of crude oil over this period has fluctuated over an incredible range, from as low as $3 (U.S.) per barrel to as high as $35 per barrel.
>
> Another key variable has been the changing role of oil in the world economy, and particularly in the industrialized OECD countries.
>
> The link between oil demand and economic growth in the OECD countries has been weakened in the last decade by changes in the economic structure of the industrialized economies (gradual increase in importance of the service

sector), by cost-inspired breakthroughs in the technology of crude oil conservation (e.g., more efficient automobiles, improved home insulation), and by development of interfuel substitution (in particular, the use of natural gas, coal and electricity by industry).

A region's dependence on oil for its energy needs depends obviously on the relative abundance of other energy resources in that region (witness Canada's low dependence on oil, thanks to the variety of alternative energy sources that were developed during the high oil price era)[2].

Canada's successful energy diversification has therefore weakened the initial rationale of security of supply. Coincidentally, the comparative cost advantage of substitute energy sources has become a very important factor.

In recent years many questions regarding the relative cost efficiency of nuclear power have arisen:

- cost/schedule overruns at the Darlington generating station;
- repair problems at Bruce;
- the high debt load of Ontario Hydro; and,
- sharp increases in industry and consumer power rates.

The definition of cost effective energy has been steadily expanded, to include the price tag from environmental and health considerations. The whole fuel cycle is being examined, from the extraction of gas, mining of coal or uranium, through the transportation phase to burning and waste disposal, emissions and decommissioning. Environmental activists, consumer groups and industrial groups have been directing increased criticism towards the nuclear energy option, research and any further development of the sector in Canada. The debate on how Canada's energy requirements will be met are a permanent feature of the political landscape.

[2]Stability Within Uncertainty: Evolution of the World Oil Market, Study No.28, September 1988. Anthony E. Reinsch, Kevin J. Brown, James O. Stanford (p.3-30)

Section Two: The Canadian Nuclear Industry

The purpose of this section is to provide a brief overview of the Canadian nuclear industry - specifically its history, structure, activities, opportunities and challenges. The information is drawn primarily from our review of existing information.

2.1 A Brief History

The Origins of AECL and the CANDU Reactor

Atomic Energy of Canada Limited (AECL), a Crown corporation, was created by an Act of Parliament in 1952. During the 1950s, AECL, in co-operation with Canadian General Electric and Ontario Hydro, designed and developed the CANDU (CANadian Deuterium Uranium) reactor. Although all nuclear reactors are based on the same principle[3], CANDU reactors use heavy water (deuterium oxide) as the neutron moderator. This unique technology of using a heavy water moderator means that CANDU reactors use natural uranium (rather than enriched uranium) as the source of fuel to create the nuclear reaction. Heavy water is also used as a coolant for the reactor.[4]

Commercialization

Commercialization of CANDU reactors in Canada was undertaken in sequential steps. First, the industry proceeded through several demonstration phases. Shortly after its formation, AECL, in partnership with Ontario Hydro and General Electric, made a significant step into the electrical generating field by designing and constructing a 25-megawatt

[3] A nuclear reactor creates heat by splitting uranium atoms. This is called nuclear fission. When the nucleus of an atom, such as uranium, is struck by a neutron traveling at the right speed, it splits into fragments which separate rapidly and generate heat. It also gives off a few neutrons. In order to sustain a continuous nuclear reaction, the speed of these neutrons must be moderated, to facilitate their capture by other uranium atoms and thus leading to further fission.
[4] CNA Fact Sheet, 1992

nuclear plant demonstration (NPD) at Rolphton and by formally establishing a Nuclear Power Plant Division (now AECL CANDU). Completion of the NPD in 1962 marked the first feed of electricity generated by a nuclear power plant into a Canadian electrical grid.

In 1958, before the completion of the plant at Rolphton, it was decided that AECL and Ontario Hydro would build a 200-megawatt commercial prototype at Douglas Point on Lake Huron. This prototype went on stream in January 1967.

In 1963, AECL made its entry into full-scale commercial power generation when it again teamed with Ontario Hydro to build a two-unit 1100-Megawatt station at Pickering, on Lake Ontario. Gentilly 1, a prototype reactor in Quebec was completed in 1970. In 1971 the first fully commercial CANDU reactor, Pickering 1, went into service.

Nuclear's Share of Canada's Electricity

While AECL owned the demonstration and prototype CANDU units, NPD and Douglas Point, it took an equity share in Pickering 1 and Pickering 2, which also came on-line in 1971. The other owners were Ontario Hydro and the Ontario government.

Further units in Ontario were fully financed by Ontario Hydro, with AECL contracted to provide a diminishing share of the engineering work, mainly on the core and control systems.

Pickering 3 started commercial operation in 1972 and Pickering 4 in 1973. The four units at Pickering made up the Pickering 'A' nuclear generating station.

The original intent of Canada's nuclear program was to turn the design and engineering functions over to private industry as well. General Electric Canada (GE Canada) was closely involved as a partner in the early designs. However, Ontario Hydro did not want to depend on just one private-sector supplier, and preferred to use a joint Hydro/AECL design team within AECL, to which it seconded key engineers.

Private-sector firms took on the role of manufacturing components and of performing some consulting, construction and project management services.

The lineage of CANDU designs evolved. In 1977 a larger station, Bruce 1, the first of four units at the Bruce 'A' nuclear generating station started commercially.

Ontario Hydro and AECL, after their initial close cooperation in the development of the CANDU, developed different products for different markets from the mid-1970s onwards.

In Ontario, Hydro expanded its in-house design, engineering and project management capabilities to look after its own very large nuclear operation and construction program, and to develop evolutionary versions of its multi-unit designs for Ontario, while AECL played a more entrepreneurial role in new designs for markets outside Ontario.

AECL played a variety of roles in the building of CANDU 6 units, mainly as designer and consultant. The CANDU 6 type of reactor was developed from the Pickering 'A' station. Hydro Quebec's commercial nuclear electricity program began and continues to consist of Gentilly 2, commercially in-service as of 1983. Point-Lepreau in New Brunswick also started commercial operation that same year.

From 1983 through 1986 Pickering units 5,6,7 and 8 began feeding into Ontario's electricity. Likewise, from 1984 through 1987, the four units that comprise Bruce Nuclear Generating System 'B' went commercial.

Though much of the existing domestic capacity came on-stream in the late 1970s and throughout the 1980s, these projects were mainly launched well before then. Annual electricity growth slowed down in the late 1970s and early 1980s. In Canada, the 1980s marked the beginning of an era in which additions to generating capacity generally, and nuclear in particular, began to be deferred.

Dependent for new reactor work on the anticipated growth rates in electricity demand, and on its share of new orders to meet the demand, AECL CANDU was forced in the 1980s to downsize from approximately 3000 personnel to about 1100. All nuclear designers and vendors worldwide faced similar problems.

Thus, construction of the four Darlington reactors was approved by the Provincial Government of Ontario in the late 1970s and commercial operation at the Darlington Nuclear Generating Station began in the early 1990s.

By 1992, there were 22 commercial nuclear power reactors in Ontario, New Brunswick and Quebec. These reactors, summarized in Exhibit 2.1, have generated 1 billion MWh of power during their life. In 1992, these units generated 76 million MWh of electricity valued at $3.7 billion[5].

[5] Source: Statistics Canada Catalogue, 57-001, 1992

Exhibit 2.1 - Summary of Canadian Commercial Nuclear Power Reactors, 1992

	Lifetime Power (million MWh)	Capacity (MW gross)	Commercial Start	Construction Time[6] (Years)
Gentilly 2	41.9	685	1983	8.0
Point Lepreau	54.8	680	1983	7.0
Pickering 1	65.6	542	1971	6.8
Pickering 2	60.9	542	1971	7.2
Pickering 3	68.2	542	1972	7.6
Pickering 4	66.1	542	1973	8.8
Bruce 1	81.4	904	1977	8.8
Bruce 2	72.9	904	1977	8.8
Bruce 3	87.7	904	1978	9.3
Bruce 4	81.6	904	1979	10.2
Pickering 5	35.8	540	1983	8.5
Pickering 6	36.0	540	1984	9.6
Pickering 7	31.7	540	1985	10.5
Pickering 8	27.6	540	1986	11.7
Bruce 5	52.5	915	1985	9.3
Bruce 6	53.3	890	1984	8.9
Bruce 7	43.5	915	1986	10.4
Bruce 8	35.2	890	1987	11.6
Darlington 1	----	935	1992	12.8
Darlington 2	1.4	935	1990	12.2
Darlington 3	----	935	1993	13.8
Darlington 4	----	935	1993	14.6

Source: NUKEM Special Report, CANDU Owner's Group, Ontario Hydro, CNS and CANDU Updates, 1992 and Nuclear News, September, 1993.

In 1992, nuclear energy supplied 15% of Canada's electricity requirements. As shown in Exhibit 2.2, this marks a growth from 0.5% in 1970.

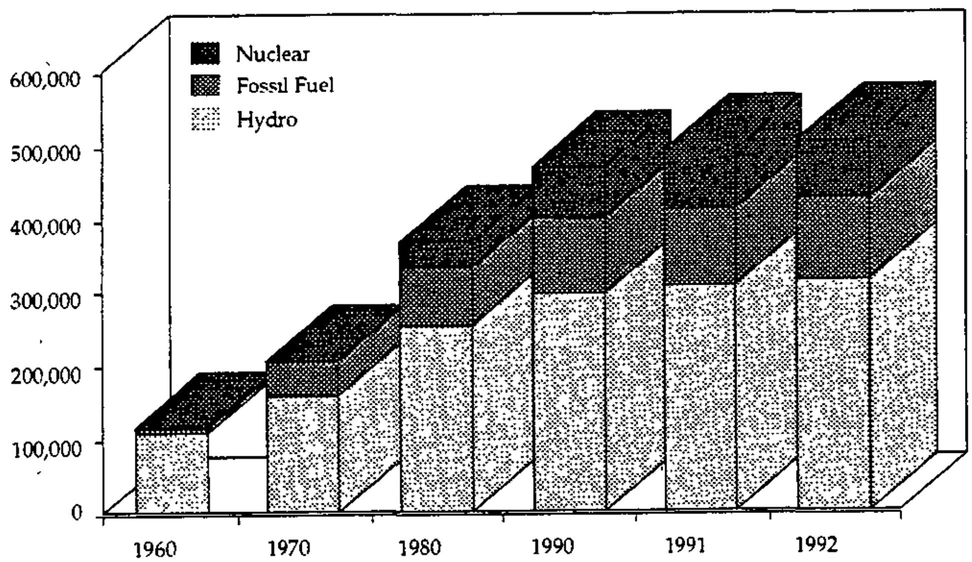
[6] Construction time denotes from date when the project was committed to the time when the reactor unit is actually in service.

Exhibit 2.2 - Sources of Canadian Electricity (GWh)

	1960	1970	1980	1990	1991	1992
Hydro	105,883	156,709	251,217	292,810	304,296	312,133
Fossil Fuel	8,495	47,045	80,207	104,121	104,776	113,369
Nuclear	0	969	35,882	68,837	80,123	76,021
Total	114,378	204,723	367,306	465,768	489,195	501,523
Nuclear Share	**0%**	**0.5%**	**10%**	**15%**	**16%**	**15%**

Source: Statistics Canada, 57-001, 1992 and Summary of Energy, Electricity and Nuclear Data, 1993, AECL.

Source of Canadian Electricity (GWh)



With the completion of the Darlington station in 1993, nuclear energy provides almost 20% of Canada's electricity. This compares with about 20% in the United States, 30% in Japan, 36% in Germany and 75% in France.[7] Exhibit 2.3 shows that in 1992 nuclear energy provided 48% of Ontario's, 30% of New Brunswick's and 3% of Quebec's electricity supply.

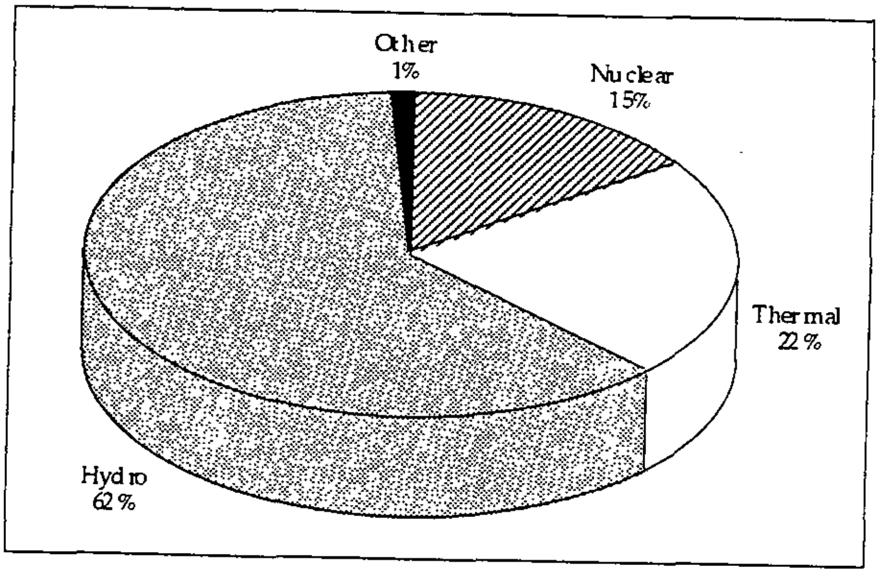
[7]Canadian Energy Assessment, World Energy Council, 1993.

Exhibit 2.3 - Electrical Energy Production by Fuel Type and Province in 1992 (GWh)

Province	Hydro	Thermal	Nuclear	Other	1992 TOTAL	1992 %
Nfld.	34,880	1,801	0	0	36,681	7%
P.E.I	0	34	0	0	34	- %
N.S	896	8,670	0	156	9,722	2%
N.B	2,972	7,882	4,835	273	15,962	3%
Quebec	141,352	1,125	4,600	0	147,077	29%
Ontario	39,719	30,457	66,587	1,755	138,518	27%
Manitoba	26,434	279	0	50	26,763	5%
Saskatchewan	3,055	10,894	0	178	14,127	2%
Alberta	1,585	44,565	0	1,370	47,520	10%
B.C.	60,555	2,007	0	1,496	64,058	13%
Yukon	419	61	0	0	480	1%
N.W.T	267	314	0	0	581	1%
CANADA	312,134	108,089	76,022	5,278	501,523	100%
Breakdown (%)	62%	22%	15%	1%		

Source: Energy, Mines and Resources Canada, 1991, Statistics Canada, 57-001, 1992 and Summary of Energy, Electricity and Nuclear Data, 1993, AECL.

Canada Electrical Energy Production by Fuel Type, 1992



International Markets

At first, both AECL CANDU and Canadian General Electric (CGE) were actively pursuing international markets for CANDU reactors. AECL began on a small scale in 1963 with the signing of contracts to build a unit in India (Rapp 1). Three years later, in 1966, Rapp 2 was also sold to India. Both of these units were based on the design of the AECL Douglas Point commercial prototype.

In 1965, CGE, now GE Canada, made a successful bid to Pakistan for another CANDU reactor, Kanupp. Until 1967, CGE lead the marketing of CANDU stations internationally. However, after CGE bids to Argentina and Finland failed to materialize and without a domestic Canadian reactor base, the company withdrew from the reactor vending business. GE continues to design and manufacture such essential CANDU components as fuel bundles and fueling machines, but the lead role in overseas marketing has been assumed by AECL.

AECL's first large-scale CANDU export was negotiated with Argentina in 1974. In 1976, the first CANDU reactor was sold to South Korea. Three years later, a sales agreement was reached with Romania. Then began a significant period of nine years without any export sales success. However, the export market developed quickly in the early 1990's. In a little over two years, AECL CANDU:

- sold three CANDU 6 plants to Korea Electric Power Company (KEPCO) in South Korea;
- secured a contract with the Romanian utility RENEL to complete the Cernavoda 1 reactor; and,
- maintained sales of engineering and R&D services from CANDU plant operators in Canada and abroad at the 1980s level of about $100 million annually[8].

[8]AECL estimates, 1993

As of 1992, 13 CANDU reactors had been sold to the following five countries:

Exhibit 2.4 - CANDU Exports as of 1992

Country	Reactor	Capacity (MWe gross)	In-Service
Pakistan	Kanupp 1	137	1972
India	Rapp 1	220	1973
	Rapp 2	220	1981
Argentina	Embalse	648	1984
South Korea	Wolsong 1	700	1983
	Wolsong 2	700	1997
	Wolsong 3	700	1998
	Wolsong 4	700	1999
Romania[1]	Cernavoda 1	679	1994
	Cernavoda 2	679	-
	Cernavoda 3	679	-
	Cernavoda 4	679	-
	Cernavoda 5	679	-

Source: AECL Estimates

Note: (1) Romania has undertaken some construction work on the buildings for Cernavoda units 2, 3, 4 and 5, but has not ordered any equipment for these reactors. Completion dates remain uncertain.

In 1992, CANDU reactors had captured seven percent of the world's market share of operating nuclear reactors and over ten percent of nuclear reactors under construction.

Performance of CANDU Reactors

Any one performance indicator, or set thereof, provide only a partial and time-delayed perspective. They are best used in conjunction with other assessment tools and not as the sole basis for judgment or decisions.

At the end of 1992, New Brunswick's Point Lepreau reactor remained in the top ranking worldwide (for units over 150 MW) for maintaining one of the highest percentage of full capacity in producing electricity since the unit began operating. On this measure of reliability, or lifetime load factor, six of the top ten reactors in the world in 1988 were CANDUs. Exhibit 2.5 highlights these top performing reactors and tracks their performance record from 1988 to the end of 1992. In 1988, these CANDU placings were from the 322 reactors of 150 MW and over which had operated for one year or more at the time they were ranked. The base for comparison grew to 361 reactors in 1992.

Exhibit 2.5 - International Rankings of CANDU Reactors, Comparison of 1988 -1992 by cumulative (lifetime) load factor at end of each year

Reactors Size: 150MWe+Gross	International Rankings 1988	1990	1992
Pickering 7	1	9	8
Point Lepreau	2	1	3
Pickering 8	6	12	6
Bruce 5	7	4	11
Bruce 6	9	17	26
Pickering 6	10	15	13

Source: Nuclear Engineering International, 1988 - 1992.

It is apparent that the relative performance of CANDUs has suffered in recent years, specifically the CANDU Pressurized Heavy Water (CANDU - PHW) type of nuclear - electric generating stations developed jointly by AECL and Ontario Hydro and the Pickering "A" and Bruce "A" units in particular. By the end of 1992 three of the top ten reactors in the world for lifetime load factors were CANDUs. Impressive, but a reduction nonetheless in the number of CANDUs ranking among the world's best.

As shown in Exhibit 2.6 the average annual capacity factors of Canadian units has see-sawed over the last four years.

Exhibit 2.6 - Annual average capacity factor by reactor units in Canada

Year	No.of Units	Capacity Factor
1989	18	73.63%
1990	19	61.33%
1991	19	71.49%
1992	20	68.09%

The following charts also confirm the volatile performance of the Canadian CANDU reactors from 1990 to 1992. Exhibit 2.7, 2.8 & 2.9 indicate that only Pickering 8 appears among the top 50 reactors three years in a row and of the two other unit in Canada that appear twice, Pickering 6 has fallen substantially in the rankings[9].

Exhibit 2.7 - Canadian units in the top 50 performers by annual capacity factor, 1990

Pt. Lepreau	#7	95.93
Bruce 7	#29	88.76
Pickering 8	#42	86.91

Exhibit 2.8 - Canadian units in top 50 performers by annual capacity factor, 1991

Pickering 6	#2	99.75
Pickering 8	#5	99.23
Pt. Lepreau	#7	97.66
Pickering 7	#16	95.06
Bruce 6	#22	93.24
Bruce 8	#26	92.29
Bruce 5	#38	90.02

9 Nucleonics Week. 1991, 1992, 1993 Nuclear Plant Performance By Vendor And Nation. One other CANDU unit, Wolsong 1 in South Korea, placed in the top 50. It was ranked 49th in 1990, 35th in 1991 and 50th in 1992.

Exhibit 2.9 - Canadian units in the top 50 performers by annual capacity factor, 1992

Pickering 8	#13	93.52
Pickering 2	#28	90.81
Pickering 6	#33	90.17
Pickering 3	#36	82.94

The CANDU Owners Group (COG) recently reported:

> In the original CANDU concept the use of on-power refueling, dictated by the choice of natural uranium fuel, was expected to offer a major benefit in terms of high capacity factor. The elimination of batch refueling combined with design features to facilitate on-line testing and maintenance, was supposed to minimize the need for planned shutdowns except for periodic testing and inspection. While this still remains generally true, performance of the older CANDU units has tended to deteriorate in recent years.[10].

2.2 Structure of the Canadian Nuclear Industry

The Main Players and Their Roles

The most significant members of the nuclear community are AECL, the Atomic Energy Control Board (AECB), provincial utilities, mining companies, equipment manufacturers and engineering companies.

Atomic Energy of Canada Limited is the main innovator of nuclear technology in Canada. The Crown corporation operates through AECL CANDU and AECL Research as one company with one mission. AECL's mission is:

[10] Performance of CANDUs: 1971-1993, COG.

AECL Mission

We will secure the maximum economic benefit for Canada from the CANDU technology and associated research and development: the CANDU Business.

The CANDU Business has three key components:

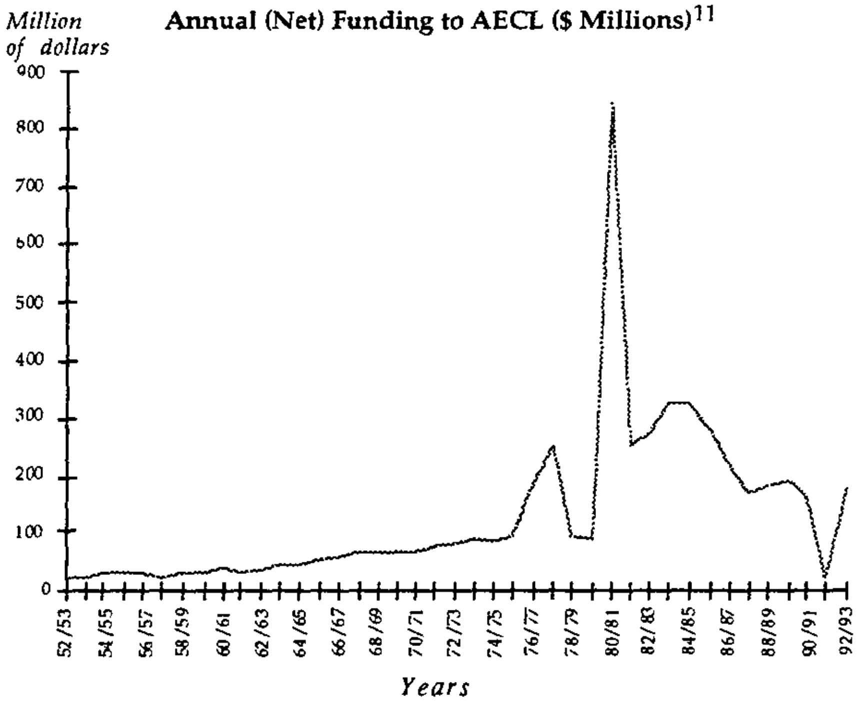
- Developing and marketing CANDU plants to secure a major share of the global market for nuclear plants, managing the associated build projects and performing the R&D to ensure long-term competitiveness.
- Developing and marketing services to CANDU plants and, where appropriate, developing non-CANDU business opportunities that enhance CANDU business prospects.
- Developing and applying underlying knowledge in energy, environment and health that enhances CANDU business prospects or supports Canada's nuclear policies and initiatives.

These mean meeting customer requirements with quality products and service

Source: Atomic Energy of Canada Limited, Corporate Plan 1993/94 to 1997/98

As shown in Exhibit 2.10 and 2.11, net government funding to AECL between 1952 and 1992 amounted to $4.7 billion in as-spent dollars.

Exhibit 2.10
Annual (Net) Funding to AECL ($ Millions)[11]



[11] The Government of Canada approved a significant financial reorganization of AECL effective April 1, 1980. This reorganization consisted primarily of the forgiveness of the loans and advances due to the Government with respect to the purchase, rehabilitation, and construction of heavy water plants.

Exhibit 2.11
TOTAL FUNDING TO AECL
($ MILLIONS)

	A	B		C	D	E					
		NPR									
Year	R&D	Funding	Pickering Pay-back	CANDU 3	Slowpoke	Loans Forgiven	HWP Loans Payment	Pd'n Support	Plant Closure/ Safekeeping	Dividends	Total
52/53	21.4	-	-	-	-	-	-	-	-		21.4
53/54	19.6	-	-	-	-	-	-	-	-	-	19.6
54/55	29.5	-	-	-	-	-	-	-	-	-	29.5
55/56	30.3	-	-	-	-	-	-	-	-	-	30.3
56/57	30.5	0.5	-	-	-	-	-	-	-	-	31.0
57/58	23.8	0.8	-	-	-	-	-	-	-	-	24.6
58/59	26.6	2.1	-	-	-	-	-	-	-	-	28.7
59/60	24.7	5.8	-	-	-	-	-	-	-	-	30.5
60/61	26.5	11.7	-	-	-	-	-	-	-	-	38.2
61/62	29.1	4.8	-	-	-	-		-	-	-	33.9
62/63	37.1	-	-	-	-	-	-	-	-	-	37.1
63/64	44.9	-	-	-	-	-	-	-	-	-	44.9
64/65	45.2	-	-	-	-	-	-	-	-	-	45.2
65/66	52.7	-	-	-	-	-	-	-	-	-	52.7
66/67	58.0	-	-	-	-	-	-	-	-	-	58.0
67/68	66.5	-	-	-	-	-	-	-	-	-	66.5
68/69	68.6	-	-	-	-	-	-	-	-	-	68.6
69/70	69.0	-	-	-	-	-	-	-	-	-	69.0
70/71	68.9	-	-	-	-	-		-	-	-	68.9
71/72	77.0	-	-	-	-	-	-	-	-	-	77.0
72/73	78.2	-	-	-	-	-	-	-	-	-	78.2
73/74	87.9	-	-	-	-	-	-	-	-	-	87.9
74/75	85.9	-	-	-	-		-	-	-	-	85.9
75/76	93.6	-	-	-	-	-	-	-	-	-	93.6
76/77	96.8	85.5	-	-	-	-	-	13.3 [3]	-	-	195.6
77/78	101.7	151.3 [1]	(28.1)	-	-	-	-	26.8 [3]	-	-	251.7
78/79	110.3	8.9	(23.3)	-	-	-	-	-	-	-	95.9
79/80	114.7	8.8	(32.7)	-	-	-	-	-	-	-	90.8
80/81	123.1	10.2	(30.5)	-	-	672.2 [2]	-	65.0	9.0	-	849.6
81/82	145.7	11.4	(29.9)	-	-	-	9.3	113.0	5.0	-	254.5
82/83	169.9	12.7	(38.1)	-	-	-	11.3	118.3	3.1	-	277.2
83/84	184.5	12.4	(13.0)	-	-	-	12.3	124.7	2.5	-	323.4
84/85	192.4	11.1	-	-	2.6 [4]	-	12.3	104.6	2.5	-	325.5
85/86	172.7	18.3	-	-	3.9 [4]	-	13.3	29.2	37.7	-	275.1
86/87	176.8	11.9	-	-	4.9 [4]	-	3.3	-	20.7	-	217.6
87/88	143.3	15.2	-	-	10.4	-	3.3	(8.3)	3.2	-	167.1
88/89	135.9	5.0	-	44.4	11.1	-	3.3	(6.1)	3.5	(16.4)	180.7
89/90	141.5	6.0	-	29.2	12.2	-	3.3	(3.7)	4.3	-	192.8
90/91	154.3	-	-	-	-	-	3.3	(5.7)	9.8	-	161.7
91/92	162.1	-	-	-	-	-	3.3	(2.4)	10.5	(152.5)	21.0
92/93	167.3	-	-	-	-	-	3.3	(6.1)	10.9	-	175.4
Ending inventory book value			-	-	-	-	-	(522.5)	-	-	(522.5)
	3,688.5	394.4	(195.6)	73.6	45.1	672.8	81.6	40.1	122.7	(168.9)	4,754.3

Notes

1. Excludes non-cash contribution of $124.1 M respecting accrued interest on loans used to finance the prototype nuclear power reactors
2. Excludes non-cash contribution of $157.4 M respecting accrued interest on loans used to finance the heavy water plants.
3. Appropriations used to cover operating losses in Heavy Water Projects c[illegible]tions
4. The annual split is on an estimated basis.

* Source AECL Annual Report

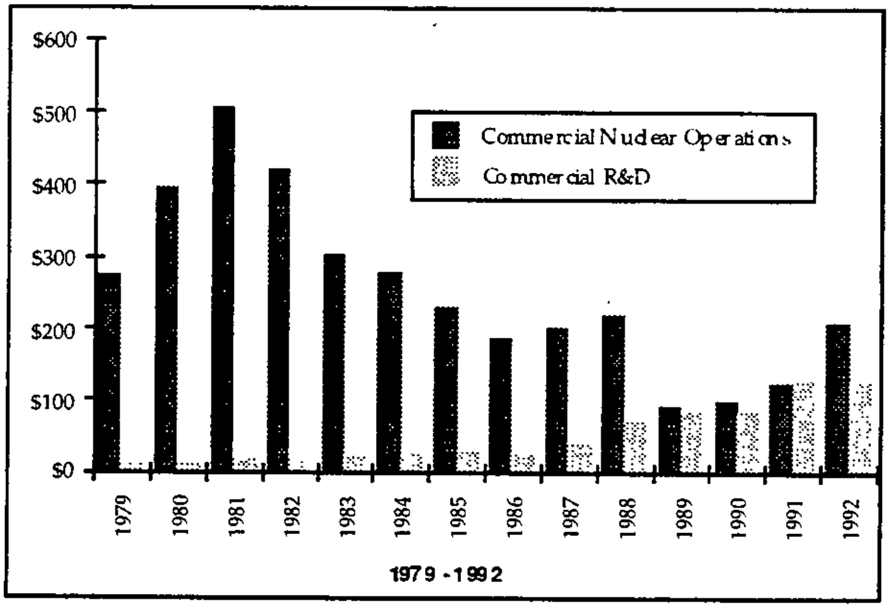
Exhibit 2.11 also illustrates how these expenditures were allocated to different AECL activities.

As shown in Exhibit 2.12, AECL generates revenues from nuclear operations and R&D revenues. Between 1989 and 1992, AECL revenues from these sources have increased. Specifically, revenues from nuclear operations have increased by 69% and R&D revenues have increased by 54%.

Exhibit 2.12 - Selected AECL Revenues ($ million), 1979 to 1992

	Revenues from commercial nuclear operations[12]	Revenues from cost sharing and commercial R&D	Total
1979	$272	$12	$284
1980	$395	$12	$407
1981	$503	$17	$520
1982	$418	$19	$437
1983	$303	$22	$325
1984	$276	$24	$300
1985	$229	$27	$256
1986	$186	$25	$211
1987	$199	$38	$237
1988	$219	$67	$286
1989	$89	$82	$171
1990	$99	$82	$181
1991	$122	$127	$249
1992	$209	$126	$335
Total	**$3519**	**$680**	**$4,199**

Source: AECL Annual Reports, 1979-1993



[12] Does not include revenue from financing activities

AECL CANDU: As part of its mandate, AECL CANDU designs, engineers and markets CANDU nuclear power projects in Canada and abroad. It also manages the contracts for building and servicing them. Federal dollars are not appropriated for this activity. AECL CANDU is based in Mississauga, Ontario and Montreal, Quebec and has offices around the world.

Although AECL export revenues are reflected in the revenues from commercial nuclear operations, they are separated in Exhibit 2.13 to show the important contribution of international business to AECL's revenues.

Exhibit 2.13 - AECL Export Revenues

	Revenues from commercial nuclear operations	Export revenues	Exports as % of commercial revenues
1979	$272	-	-
1980	$395	$318	81%
1981	$503	$397	86%
1982	$418	$308	75%
1983	$303	$217	72%
1984	$276	$195	71%
1985	$229	$145	63%
1986	$186	$141	76%
1987	$199	$150	75%
1988	$219	$179	82%
1989	$89	$121	76%
1990	$99	$54	55%
1991	$122	$100	82%
1992	$209	$151	61%
Total	**$3519**	**$2476**	**70%**

Source: AECL Annual Reports, 1979-1992

AECL export revenues diminished in 1990 with the "spinning off" and subsequent privatization of Nordion and Theratronics. However, export revenues increased considerably in 1991 and 1992 from the Wolsong 2, 3 and 4 reactor sales to South Korea.

Looking forward, the stated goal for AECL CANDU is to capture at least a quarter of the emerging global market for the next generation of nuclear power plants.

AECL Research is the main nuclear research organization in Canada with a 1992 budget of approximately $300 million for its laboratories at Chalk River, Ontario and Pinawa, Manitoba. Last year AECL had the third highest level of investment in research and development among companies in Canada[13].

In 1992, fifty-six percent of AECL's R&D spending was funded by the federal government, 30 percent by the provincial utilities, and 14 percent by commercial revenues[14]. In dollar terms, AECL derives approximately $80 million annually from Ontario Hydro for R&D support[15].

CANDU Owners Group (COG), was formed in mid-1984 by the Canadian CANDU-owning utilities and AECL. The purpose of COG is to provide a framework that will promote closer cooperation among the utilities owning and operating CANDU stations in matters relating to plant operations and maintenance, and to foster cooperative development programs leading to improved plant performance.

The Atomic Energy Control Board (AECB), an agency of the federal government, regulates nuclear activity in Canada. Established in 1946 by the Atomic Energy Control Act, the AECB controls the development, application and use of nuclear energy in Canada, and participates, on behalf of Canada, in international measures of control. The AECB achieves regulatory control of nuclear facilities and nuclear materials through a comprehensive licensing system. This control also extends to the import and export of nuclear materials, and it involves Canadian participation in the activities of the International Atomic Energy Agency as well as compliance with the requirements of the Treaty on the Non-Proliferation of Nuclear

[13]The R&D Top 100, Report on Business Magazine, September 1993
[14] Source: Interview with AECL Research staff in Ottawa, 1993
[15] Source: Interview with Ontario Hydro, 1993

Weapons. The control covers both domestic and international security of nuclear materials and technology. More specifically, the AECB maintains regulatory control over the following[16]:

- power and research reactors;
- uranium mines and mills;
- uranium refining and conversion facilities;
- fuel fabrication facilities;
- heavy water production plants;
- particle accelerators;
- radioactive waste management facilities:
- prescribed substances and items; and,
- radioisotopes.

Failure to satisfy AECB requirements with respect to any of the above can result in the closure of a nuclear installation or the placement of a limitation on the level of power that may be generated by the installation.

Agencies for International Supervision: The basic objectives of Canada's nuclear non-proliferation policy are to promote and support an effective and comprehensive international non-proliferation regime. This includes assuring both domestic and international communities that Canadian nuclear exports will not be used for any nuclear explosive purpose. Presently, there are nuclear co-operation agreements between Canada and 28 countries. Key elements of Canada's nuclear non-proliferation and export policy are that nuclear co-operation is authorized to states which have:

- Made a commitment to nuclear non-proliferation by either having ratified the Nuclear Non-Proliferation Treaty, or taken an equivalent binding step;
- Agreed to accept International Atomic Energy Agency (IAEA) safeguards;

[16]Source: AECB Annual Report, 1992-1993

- Undertaken to accept in a formal agreement with Canada additional requirements designed to minimize the proliferation risk associated with Canadian nuclear exports.

Compliance with Canada's international non-proliferation commitments is assured through export permits and licenses. Exports of Canadian nuclear equipment, materials, and nuclear related technology (including nuclear reactor technology) are subject to the Export Import Permits Act and the Atomic Energy Control Act. These export controls are jointly administered by the Department of External Affairs and by the AECB.

In compliance with the Nuclear Non-Proliferation Treaty, Canadian nuclear facilities are subject to IAEA safeguards. The safeguards agreement between Canada and the IAEA is administered by the AECB.

Provincial Utilities: Ontario Hydro, New Brunswick Power and Hydro-Quebec are the three provincial utilities that own and operate the 22 nuclear reactors in Canada. They are members of the CANDU Owners Group and share in funding the industry's R&D effort.

Ontario Hydro was created in 1906 by a special provincial statute. It operates under the Power Corporation Act to deliver electricity throughout the province. Of the total number of generating units operating in Ontario in 1993, 20 of 82 were nuclear reactors. In 1992, 18 reactors were in service and they produced approximately 67 GWh which accounted for 48% of Ontario's electricity production[17].

Nuclear electricity amounted to 30% of the total electricity produced by the New Brunswick Power Corporation in 1992. New Brunswick's Point Lepreau generating station is ranked among the top nuclear power reactors in the world in terms of lifetime performance.

Hydro-Quebec was founded under a special charter by the Quebec government in 1944. Gentilly 2, Quebec's only nuclear power reactor, produces three percent of total electricity production in the province.

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[17]Source: Statistics Canada Catalogue, 1991 and Ontario Hydro Annual Reports, 1991/1992

Private Sector Industry: The nuclear industry is dynamic and opportunities for private companies emerge in cycles depending on whether new CANDU reactors are being constructed. For this reason, the number of companies varies from year to year. In 1992, we estimate that there were approximately 154 Canadian companies that supplied products and/or services to AECL and the utilities[18].

Fifty-eight percent of these firms are located in Ontario, 14% in Alberta and 12% in Quebec. The remaining provinces have 16% of the suppliers to the nuclear industry. Sixty-six percent of the nuclear industry supplier companies are in the manufacturing sector, 30% are in engineering and design and 16% are in R&D. A brief description of their role and contribution is as follows:

- Manufacturing - Manufactured components account for approximately one-quarter of the value added in the construction of a nuclear reactor[19]. Because of the cyclical nature of the nuclear industry, most of the firms producing these products are also active suppliers to other industries. The nuclear expertise provides many of these firms with a substantial competitive edge in product quality and technological status.

- Engineering - There are a number of Canadian engineering consulting firms with expertise developed through servicing the nuclear industry. Their services, including project management, are often required during plant construction.

- Operation and Maintenance - This provincial utility activity provides the largest single source of jobs in the nuclear industry. Private sector suppliers work as sub-contractors to the utilities for some of this work.

- Uranium Mining - Most of Canada's uranium deposits are found in Northern Saskatchewan and in Ontario. Since the closure of

[18] Source: 1993 Canadian Nuclear Association Yearbook and 1992 EMR Directory of Companies in the Energy Sector. Please note that these directories include only those companies who have self-identified themselves as suppliers to the nuclear industry.

[19] Source: The Future of Canadian Nuclear Industry, Uranium and Nuclear Energy Branch, EMR, 1988

Ontario's mines, the main uranium refining company in Canada is Cameco, with the world's largest high-grade uranium mine at Key Lake. The firm employs 1200 and supplies about ten percent of the Western World uranium consumption. Cameco's sales in 1992 represented nine percent of world consumption[20].

In keeping with the increasing use of nuclear energy since the 1970s, uranium consumption needed to generate nuclear power in Canada has increased steadily from a zero base in 1960 to 1517 tonnes in 1991[21]. In 1992, Canada produced 9,300 metric tonnes of uranium of which it exported 78%. The United States is the principal export market for Canada. As of 1992, Canada produced 40% of the Western world's uranium output[22].

- Construction - This activity is cyclical and has a "feast or famine" effect on employment. Construction of reactors is undertaken by general construction contractors. When nuclear facilities are being constructed, the potential employment of this sector can be large. For example, according to an Energy, Mines and Resources estimate in 1988, the construction of a CANDU 6 nuclear reactor requires 15 thousand person-years over the 7-8 years of construction[23].
- Other - In addition, over 125 hospitals and universities across Canada are involved in nuclear medicine and radiology. These organizations depend on the nuclear industry for radioisotopes.

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[20]Cameco, Annual Report, 1992
[21]Source: EMR Press Release, 1992.
[22] Source: EMR, Interview with Uranium Supply Branch, 1993
[23]Source: The Future of Canadian Nuclear Industry, Uranium and Nuclear Energy Branch, EMR, 1988

2.3 Challenges and Opportunities Facing the Nuclear Industry

What of the economic effects of the Canadian nuclear industry in the years ahead? The questions remain the same.

An AECL Vice President in 1973 asked, "Having reached this stage of our nuclear power development of achieving commercial acceptance of the CANDU system, what of the future?...Obviously few of us are prophets, so we must continually look for trends that indicate where the nuclear world is headed[24]".

There are a number of challenges and opportunities currently facing the Canadian nuclear industry.

2.3.1 Challenges

Government Support in Canada

Jake Epp, former federal Minister of Energy, Mines and Resources, reaffirmed in 1991, that:

> ....in planning to meet our needs for that most fundamental and vital commodity-energy-we want to retain all possible options. We want face the uncertainties and challenges with the strength that comes from having a range of choices[25].

Government support, at both the federal and provincial levels, has greatly assisted the development and success of the Canadian nuclear industry to date. However, the future is uncertain. It is difficult to predict the level and extent of government support for the industry in the years to come.

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[24] A.M. Aiken., Engineering Journal, March 1973

[25] "Why the World needs more Nuclear Energy", Speech by Jake Epp, former Minister of Energy, Mines and Resources, 1991.

Perception Gap Between the Public/Industry

The public in Canada perceives nuclear energy as environmentally threatening, unsafe and expensive. These perceptions remain a major obstacle to be overcome by the nuclear industry. These issues are exacerbated by a high level of misunderstanding and misinformation that surrounds the nuclear industry. The accident at Chernobyl and the widespread reaction demonstrates that serious public concerns with nuclear energy persist.

On the part of those within or supporting the nuclear industry, an observation from a British Royal Commission in the mid-1970's sums up the prevailing mind-set:

> Nuclear power has in some ways become the whipping boy for technological development as a whole....Nuclear power provides a dramatic focus for opposition in some countries to technological development and we have no doubt that some who attack it are primarily motivated by antipathy to the basic nature of industrial society, and see in nuclear power an opportunity to attack that society where it seems likely to be most vulnerable, in energy supply[26].

A sociologist at Yale University proposed in Harvard Business Review this description of the outlook among the general public:

> Most technical experts seem to assume that increased experience and familiarity will reduce the sense of dread and mystery (of toxic substances) overtime...

---

[26]Royal Commission on Environmental Pollution, United Kingdom, 1976. Reproduced in Nuclear Energy Inquiries, J.A.L. Robertson, AECL, 1993

> One of the most thoughtful pronuclear physicists notes how much easier it is to "scare" people than to "unscare" them, but his reading of human history persuades him that people will sooner or later overcome this apprehension, as they did their initial fear of electricity...
>
> The (public) fear is real, its roots deep, its effects lasting. If science and technology have become the source of risk, ... it is because toxic peril has moved people so far up the scale of suspicion that they come to distrust not only public officials and experts, not only the social order and the natural world, but also the very ethos of science and technology. And people who begin to doubt the findings of scientists and the inventions of engineers can also begin to lose confidence in logic and reason themselves-a frightening prospect by any reckoning...
>
> The one thing we cannot afford to assume as we consider how to deal with this new species of trouble is that the fear it evokes is either a passing whim or a fever that can be cooled by the calculations of experts. This dread has its own reasons; it must be respected[27].

Diminishing Domestic Demand

As a result of the economic recession and its continued effects and the energy conservation efforts of industry and the public, there has been little growth in electricity demand in most of Canada. Usage has actually fallen in Ontario.

Consequently, major utilities such as Ontario Hydro have postponed their plans to build any large new base-load facilities, including nuclear. In

[27] Harvard Business Review, January-February 1990, Toxic Reckoning: Business Faces a New Kind of Fear, by Kai Erikson.

addition, there has been some shifting from electricity to gas generation for space heating due to relative costs, and Ontario Hydro has purchased privately produced power from generating plants fueled by natural gas. For example, in 1992, Ontario Hydro purchased 2.96 million megawatt-hours of electricity from privately owned facilities (a 45% increase over 1991)[28].

With a surplus of generating capacity in 1992, Ontario Hydro put a hold on 66 proposed generating projects from private producers. Early in 1993, Ontario Hydro lifted the freeze on 50 small non-utility generation proposals under five megawatts. A decision concerning the 16 additional large projects has been delayed until they have undergone more studies.

To date, AECL's business has been closely tied to domestic electricity requirements. The challenge now is to focus its short-term efforts on expanding its market outside of Canada. In the longer term, the outlook for the Canadian market is more encouraging than at present.

Reduction in Cost Advantage

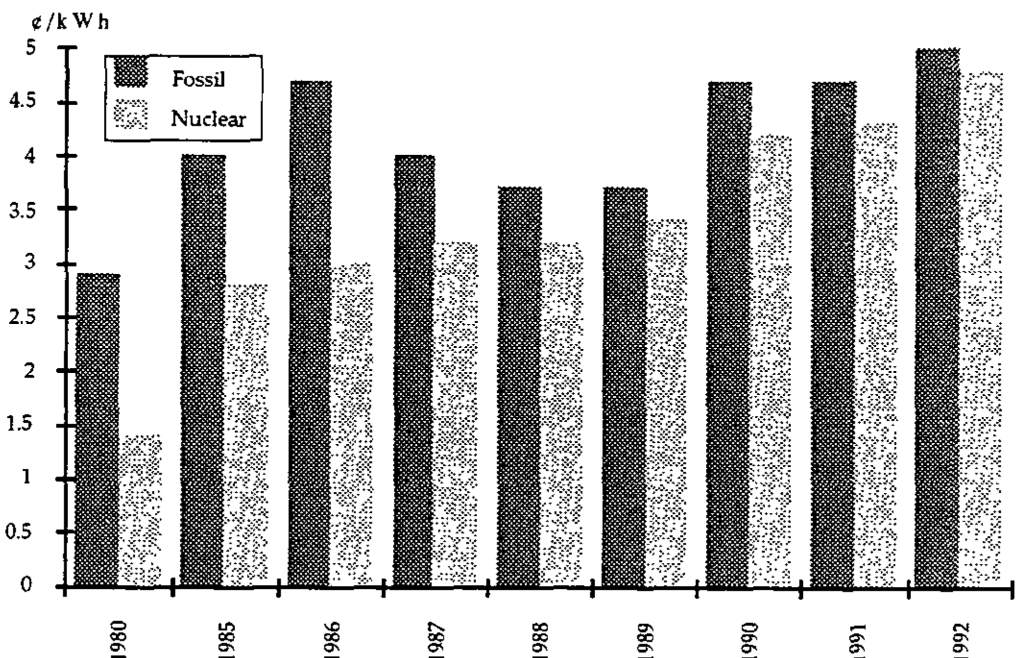
In 1992, nuclear energy in Ontario was not as cost-competitive as it was in the 1970s and early 1980s. As shown in Exhibit 2.14, the overall cost advantage of Ontario's nuclear plants vis-a-vis its fossil fuel plants (mainly coal) measured in cents per kilowatt-hour of energy generated has decreased from 35% in 1986 to 4% in 1992.

[28]Ontario Hydro, Annual Report, 1992.

Exhibit 2.14 - Cost Advantage of Nuclear Versus Fossil Fuel, 1980-1992

Year	Fossil ¢/kWh	Nuclear[29] ¢/kWh	Cost Advantage
1980	2.9	1.4	52%
1985	4.0	2.8	31%
1986	4.7	3.0	35%
1987	4.0	3.2	21%
1988	3.7	3.2	15%
1989	3.7	3.4	8%
1990	4.7	4.2	9%
1991	4.7	4.3	9%
1992	5.0	4.8	4%

Source: Ontario Hydro Annual Reports



[29]Cost includes an allowance for irradiated fuel interim storage, disposal cost and for plant decommissioning. These figures reflect the historical accounting costs of operating facilities and the actual energy generated by these facilities during the year.

This trend is contrary to that envisioned at the European Nuclear Conference in 1986 when AECL predicted that the CANDU cost advantage over coal (for generating units of 500 MW and larger in Ontario) was expected to increase from 35% in 1984 to 45% by the year 2000[30]. However, the past decade has seen falling prices for internationally traded coal. This was not anticipated.

A related issue is the relative increase in electricity costs at Ontario Hydro versus other utilities. A significant portion of the high electrical rate increases was attributed by Ontario Hydro to interest and depreciation expenses of the Darlington Nuclear Generating Station. The Municipal Electrical Association disputes whether a fair portrayal of the rate impact of Darlington has been presented to the public and whether appropriate scrutiny has been given to possible other causes.

Whatever the case, while Ontario was competitive with Quebec in the 1980s in electricity costs, the situation in 1992 saw Montreal with electricity rate of about 4.6 cents per kilowatt hour versus Toronto rates of 6.9 cents. It should be noted that Quebec has been able to bring more attractively priced hydro power into operation during this intervening time frame. Although Ontario has vast water resources, little of it has enough drop or flow to make it suitable for further hydraulic development.

In New Brunswick, given the existing electricity generating system, the traditional cost advantage of nuclear over coal is increasing. However, oil continues to hold a cost advantage over nuclear and the differential is increasing marginally.

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[30] The Costs of Power Generation-The Canadian Experience. p 71, Vol.5, ENC '86 Transactions. ENC-4: Fourth International ENS/ANS Coference and FORATOM IX: Ninth FORATOM Congress.

Ongoing Technical Issues

In recent years there have been technical problems that have brought the possible safety and cost-effectiveness of certain CANDU installations into question by the public. It was always expected that CANDU reactors would require replacement of pressure tubes during their operating lifetimes. However, the unanticipated pressure tube failures at Pickering and Bruce accelerated the consideration of this procedure at the older Ontario Hydro nuclear stations. Another case in point is the fretting and vibrating fuel bundles at the Bruce and Darlington installations.

The CANDU Owners Group recently studied the technical issues at various CANDU reactors and reported:

> Capability is a measure of a unit's or station's ability to produce electricity at its MCR (Maximum Continuous Rating), whether or not the power is delivered to the grid. To station designers and operators, it is a more meaningful measurement of performance than the more widely reported Capacity factor, since it is not affected by factors external to the station.
>
> Typically, during their early years of operation CANDUs have achieved high capability factors, in the range of 80-90%...
>
> After 8-10 years a decreasing trend in capability (appeared) for Pickering A and Bruce A. The Pickering A capability slipped to around 40% while the units were re-tubed, but has recovered to 60% and is rising steadily. The Bruce A trend has leveled off around 60% and shows little sign of turning around. The

trends for Pickering B, Bruce B and CANDU 6 have been generally holding steady in the range of 80-90%.

Conclusions

The high capability factors typically demonstrated by CANDUs during their early years of operation show a decreasing trend as older units approach "middle age". The major contributors to this trend have been inspection/replacement of pressure tubes and leaks/corrosion of steam generators. With improved understanding of the mechanisms contributing to deterioration of these components and timely application of corrective measures, the high capability of newer operating CANDUs should be maintained for a period of 20 years or more.

After about 20 years, retubing of the reactor plus rehabilitation or replacement of aging and obsolete equipment are expected to restore performance. With a new reactor core and refurbished systems and equipment, there is every expectation that the economic lives of existing CANDUs can be extended to 40 years or more at high capability factors. The demonstrated performance of the Pickering A units after retubing supports this expectation[31].

Due to the complex and evolving design of CANDU reactors, technical issues are likely to be a continuous challenge.

[31] Performance of CANDUs: 1971-1993, COG

Managing Fuel Waste

Resolving the spent fuel management issue is one of the essentials to moving forward with the nuclear energy option in Canada. Indeed, establishing a permanent disposal method is a challenge that has been undertaken by all major nuclear power producing nations.

About 1 million kilowatt hours of electricity are generated from the fissioning of material in a single CANDU fuel bundle. Each bundle contains about 22 kg of uranium dioxide and, as of the end of 1990, 800,000 bundles were in storage at the Canadian generating stations. Spent fuel from a power reactor is highly radioactive and remains so for a long time.

The bundles are stored in water-filled pools or dry storage containers and, although these methods of storage are proven to be safe, they require monitoring and upkeep throughout their lifetime. Thus, a method is required to deal permanently with waste in such a way that there needs to be no long-term monitoring.

Although it is technically feasible to re-process the waste and recycle fissionable material back to the power reactors, there are no plans to do so domestically since the method is not cost effective. Canada has copious amounts of accessible uranium deposits. Re-processing also offers no incentive in terms of reducing the size of a disposal facility or the risk of radiological exposure.

The overall objective in Canada has been to find a technology for the disposal of waste that will ensure no significant adverse effect on man or the environment at any time. AECL has proposed a concept that is similar to those being considered by numerous other nations: geological burial. In Canada it is thought that waste in sealed containers placed in compartments drilled into the granite of the Pre-Cambrian shield will be ideal. The Canadian Shield is amongst the oldest and most stable rock belts on earth.

In 1981 the Governments of Canada and Ontario announced a review process for the used nuclear fuel disposal concept.

In 1988 the Minister of Energy, Mines and Resources referred the waste disposal concept to the Minister of the Environment for review by an Environmental Assessment Panel under the Environmental Assessment and Review Process (EARP).

In early 1994, AECL will be submitting its Environmental Impact Statement to the independent Environmental Assessment Panel. Even assuming the concept does win government approval, the selection of a disposal site will cause the challenge to be transferred from the areas of science and engineering to management and politics.

Maintaining the Supply Base

At this time, manufacturers who supply the nuclear industry typically use only 50 percent of their overall capacity for this purpose (discussed further in Section Five). Due to the uncertainty of the nuclear market, those manufacturers supplying the industry usually also remain active in other industries. It is this diversification that has allowed Canada to retain capability during particularly slow periods. However, as and when nuclear work become available, these companies must displace their current production or expand their facilities to accommodate the new nuclear contracts. This results in higher production costs since additional resources are needed to fulfill the contracts. Also, if the delay between nuclear contracts is too long, attrition erodes the base of skilled manufacturing workers, so time and money is required to train and qualify new staff. The higher costs and longer schedules resulting from such manufacturing complications could make the CANDU less competitive in the international markets.

Availability of Qualified Human Resources

The lack of a stable supply of scientists and engineers also poses a challenge to the Canadian nuclear industry[32]. In response, AECL Research leads several programs aimed at motivating students into the sciences. For example, AECL Research runs an Education Partnerships programs with schools in the Renfrew County, Eastern Manitoba and Immaculata High School in Ottawa. The Chalk River Laboratories host annual Science for Educators Seminars. As well, Deep River and Pinawa have established on-site science academies that instruct promising students during the summertime. As part of its hiring practice, AECL Research employs promising post-graduates and they earn their graduate degrees while on the job[33].

Finding enough scientists and engineers is a challenge that extends well beyond the nuclear community - it is problematic to the nation as a whole and its resolution will require a national effort.

2.3.2 Opportunities

Future Global Energy Needs

Although the demand for new generating capacity has recently declined in the West, world energy consumption is forecast to increase steadily over the next two decades.

The World Energy Council (WEC) established the Commission "Energy for Tomorrow's World" to provide a comprehensive up-date of long-term global and regional energy perspectives and to complement the 1987 UN World Commission's Report "Our Common Future".

In its preliminary results the Commission developed three global energy cases each representing different assumptions in terms of economic development, energy efficiencies and environmental impact. The projections of the world energy demand up to the year 2020 corresponding to these cases are presented in Exhibit 2.15.

32 This shortage has also been well documented by ISTC and the Association of Professional Engineers of Ontario and various federal and provincial task forces.
33 Source: Interviews with AECL staff, 1993

The Reference Case (REF) is in essence the same as developed by the WEC in 1989, updated by subsequent experience. The other two are variants included to illustrate sensitivities to changes in the underlying basic assumption.

> All three cases assume a sharp improvement in energy efficiency as compared with historic experience and none of them are therefore representative of any "business as usual" evolution.
>
> The Enhanced Economic Development case (EED) assumes a somewhat hither rate of economic growth in the developing countries than the Reference Case but with somewhat reduced energy efficiency. The Ecologically Driven case (ED) assumes the same economic growth as in the Reference Case, but with a sharper improvement in energy efficiency.
>
> In each of the three cases, the critically important projection of population growth is assumed to be the same, and is taken from the current UN projection - implying an explosive increase in World population from 5.3 billion in 1990 to 8.1 billion by 2020. The most striking observation in this connection is, however, that more than 90% of this increase will take place in countries which are already economically poor.[34]

The future energy demand of the three cases is distributed among three groups of countries: OCED, Central and Eastern Europe including the Newly Independent States (CEE/NIS), and the Developing Countries (DC's). As shown, total world energy demand is expected to increase anywhere from 29% to 98% between 1990 and 2020.

[34]Round Up of the 15th World Energy Council Congress, 1992

Exhibit 2.15 - Future Energy Demand in Three Groups of Countries and By Energy Form (Gigatonnes of Oil Equivalent Gtoe)

Area	1990	2020		
		REF	EED	ED
OECD	4.1	4.6	4.9	3.6
CEE/NIS	1.7	1.8	2.0	1.5
DCS	2.9	6.9	10.3	6.1
WORLD	8.7	13.3	17.2	11.2

Energy Form	1990	2020		
		REF	EED	ED
Coal	2.3	3.2	4.8	2.1
Oil	2.8	3.7	4.6	2.7
Gas	1.7	2.8	3.5	2.3
Nuclear	0.4	0.8	1.0	0.7
Hydro	0.5	1.0	1.2	0.9
New Renewable	0.2	0.5	0.8	1.5
Traditional	0.8	1.3	1.2	1.0
TOTAL	8.7	13.3	17.2	11.2

Source: Round Up of the 15th World Energy Council Congress, 1992

Based on its analysis, the International Atomic Energy Agency predicts that total world energy consumption is expected to rise from its 1991 level of 362.9 EJ to anywhere from 464 EJ to 508 EJ by 2010 and 41% to 45% of that will be used for electricity generation.

Developing nations increasingly will dominate global energy consumption in the next century, if only to meet the greater demands imposed by their burgeoning populations.

Future Global Electricity Requirements

It is thought that the demand for electricity will grow even faster than the demand for other forms of energy. Electricity will increasingly be the energy form of choice. The World Energy Council predicts that,

> Increased need for electricity... will dominate future energy demand growth worldwide. Trends in energy consumption are

> increasingly becoming dominated by the role of electricity and by the fuel choices that are made for the generation of electricity. Currently, the generation of electricity represents about one-third of global primary energy consumption. A more significant statistic is that it is likely to account for about one-half of the incremental primary energy demand growth that occurs between now and 2010...
>
> In the developing countries, which will account for 35 per cent of global energy demand growth in the coming two decades, electricity service will have high priority as a requisite for economic growth and urbanization[35].

Future Nuclear Export Opportunities

To meet these energy requirements, a number of countries are expected to invest in nuclear facilities. Given CANDU's international reputation and its recent export success, it is likely that additional export sales of CANDU will be achieved.

A senior official with the International Energy Agency/OECD recently predicted:

> All energy resources - including fossil fuels and nuclear - will be necessary for the foreseeable future (that is to say well into the next century), although the proportions of those fuels in the energy mix in different countries may well change. Renewable energy and new technologies will not be able to replace fossil fuel or nuclear...[36]

Momentum behind the environmental movement may also offer export opportunities for nuclear reactor sales. For example, it is felt that the U.S. Clean Air Act Amendments of 1990 may encourage a return to nuclear energy as the American government moves to reduce greenhouse gas

[35]World Energy Council, Journal, December 1992.

[36]Source: H. Steeg, Executive Director, IEA/OECD. Round Up of the 15th World Energy Council Congress 1992.

emissions from fossil-fired power plants. Developing nations may face internal and external pressures to modernize with a reduced reliance on fossil fuels.

Nuclear electrical capacity is expected to grow moderately in Europe in the late '90s and nuclear energy programs in the Asia Pacific region continue to expand rapidly.

While several countries, including the Netherlands, Italy and Sweden are reviewing their nuclear policies to permit the continuation, creation or expansion of nuclear power programs, Indonesia, Japan, Taiwan and South Korea have announced aggressive nuclear reactor construction programs. South Korea, in its drive to reduce its dependence on imported oil currently has nine reactors and is expected to build another 18 by the year 2006[37].

In the longer term, other countries are opening their electricity generating sectors to non-domestic companies. Countries like the United States and Hungary generate electricity from well-established nuclear programs. China National Nuclear Corporation has been authorized to move away from relying strictly on Chinese technology and components and is developing a nuclear-generated electricity program. Turkey, Thailand and Egypt could progress in the same manner.

Beyond new reactor sales, there is also a substantial nuclear base around the world already in place that requires service and modernization. As indicated in Exhibit 2.16, many nations derive a large share of their electricity from nuclear energy. In 1992, there were 423 reactors in commercial operations world-wide and 76 under construction[38].

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[37] Reuters, The Vancouver Sun, May 27.1993

[38] Source: IAEA Reference Data Series, No. 2, 1992

Exhibit 2.16 - Electricity Supplied by Nuclear Reactors, Comparison of 1988 and 1991[39]

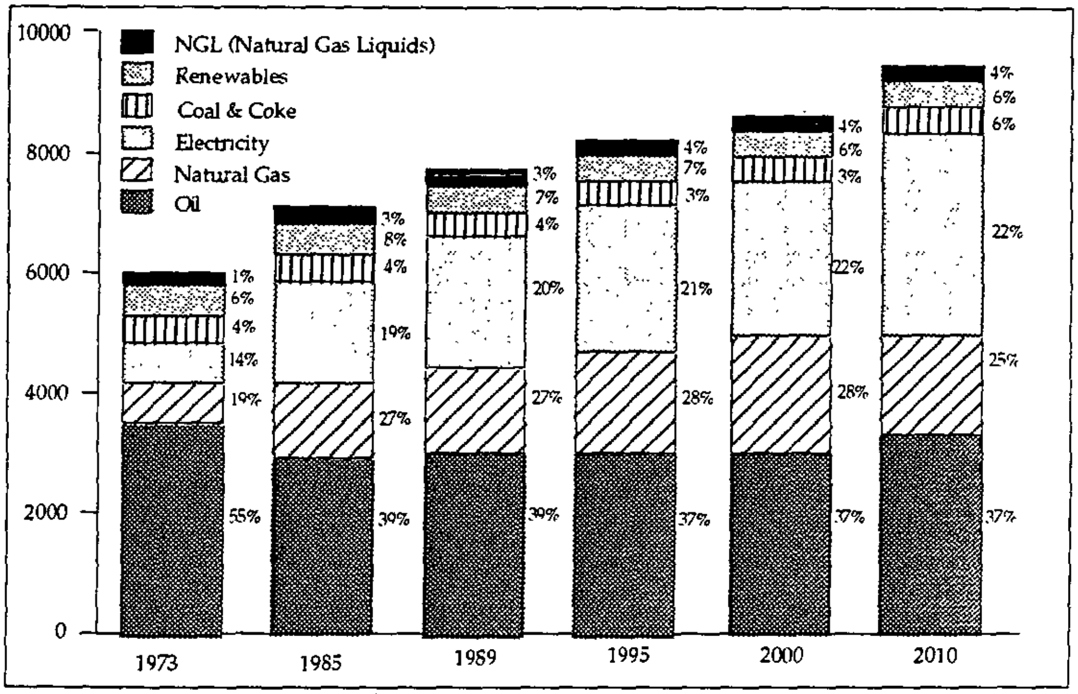
	Percent of Total Electricity 1988	1991
Canada	16%	16%
United States	20%	20%
France	70%	73%
Sweden	47%	52%
Japan	23%	24%
Bulgaria	36%	34%
Czechoslovakia	27%	29%
CIS	13%	13%
Hungary	49%	48%
South Korea	47%	48%
Taiwan, China	41%	38%
Argentina	11%	19%

Long-Term Domestic Electricity Needs

There is currently a surplus of electricity on the Canadian market. However, history has illustrated that predictions of electricity consumption and deficits can be subject to relatively significant shifts. Only three years ago at the height of an economic boom, Ontario was projecting growth needs for an additional 1000 MW of power each year. Based on Statistics Canada's forecast, Canada's electricity requirements between 1992 and 2010 will increase by 35%, as shown in Exhibit 2.17.

[39]Source: International Atomic Energy Agency, 1991, IAEA Reference Data Series No. 1, July 1992

Exhibit 2.17- 1991 Forecast of Domestic Energy Demands (GWh)[40]



Domestic Electricity Demands (GWh)[41]

	1989	1990	1991	1992	Forecast 2010	% Increase from 1992 to 2010
Canada	472,786	465,712	471,514	476,450	645,586	35%

Given these figures, and the fact that many of the commercially viable hydro sites have already been exploited, it is likely that there will be demand for new nuclear facilities. There are, for example, indications that NB Power may build a second unit at its Point Lepreau site[42].

[40] Source: Canadian Utilities and the National Energy Board, 1991

[41] Source: Canadian Utilities and the National Energy Board, 1991, Statistics Canada Catalogue 57-601, 1993

[42] New Brunswick Media Facts, February 1993

The CANDU 3

The CANDU 3, in the final stages of design, is a smaller unit of about 450 MWe, using proven CANDU components but designed to allow for faster, modular construction and greater ease of inspection and maintenance. It is intended to compete with coal-fired plants, and also with the advanced LWRs being developed in the U.S. and other countries. When adding to generating systems, today's electric utilities need flexibility in the critical exercise of matching supply with demand. They must avoid the huge financing costs and overruns that have crippled energy megaprojects in the recent past.

Uranium-Related Opportunities

Canadian uranium production and exports offer both challenges and opportunities. In terms of challenges, the emergence of inventory surpluses in the Commonwealth of Independent States (CIS) has introduced a degree of uncertainty regarding Canada's share in the global market. On the other hand, 17% of the world's electricity is generated by nuclear power and 423 reactors are in place in 25 countries[43]. Customers also prefer diversity of supply. They will therefore continue to buy from Canada, but not necessarily as much as in the past. These facts suggest that Canada's high-quality uranium will continue to enjoy export success.

Domestically, the Saskatchewan government has opened the door to further uranium development in the northern parts of the province. As a result, six new uranium mining developments are currently proceeding through the environmental review process.

[43] Source: Statistical Review of World Energy, June 1992

Section Three: Benefits of the Canadian Nuclear Industry

In documenting the benefits of the nuclear industry in Canada, we have found that many different types of economic and non-economic benefits are directly related to Canada's expertise in nuclear technology. For the purposes of describing these benefits, we have categorized them as follows:

3.1. Economic Benefits

- Impact on Gross Domestic Product
- Direct Employment
- Indirect Employment
- Sales
- Tax revenues
- Foreign exchange savings
- Exports
- Positive trade balance
- Electricity exports
- Electricity cost savings
- Regional development

3.2. Related "Spin-off" Benefits

- Medical and industrial benefits
- Other commercial spin-offs

3.3. Environmental, Agricultural and Other Benefits

- Environmental benefits
- Agricultural benefits
- Other benefits

3.1 Economic Benefits

The economic effects documented below are based on an analysis of our survey data and on the input-output analysis conducted using Statistics Canada's Open Output Determination Model. In our view, the estimated magnitudes of the impacts that we have been able to quantify are very conservative numbers and should be viewed as minimum values.

Please note that the impacts are presented in aggregate form, i.e., for the nation, as a whole. Impacts on specific regions/communities are presented only where such information/analysis was readily available.

Overall Impact on Gross Domestic Product (GDP)

Using Statistics Canada's Open Output Determination Model, we were able to approximate the impact on Canada's gross domestic product of certain segments of the nuclear industry in Canada. These segments were those relating directly to the production of electricity from nuclear power facilities and to the exports of CANDU reactor units. In the case of nuclear generated electricity, the model's calculations estimated that 90% of the total inputs needed to generate this electricity made direct contributions to the GDP. Imports constitute less than 10% of the inputs needed to generate electricity from nuclear power.

To estimate the impact on Canada's GDP of electricity generated from nuclear power, we estimated the monetary value of electricity from nuclear power for each year. This value was obtained by multiplying the total electricity production in GWh by the average cost per GWh. We then used the Open Output Determination Model to calculate what percentage of the electricity value would contribute to Canada's GDP.

In the case of CANDU exports, we used the best estimates available of the value of the Canadian content of each CANDU export reactor project that has been constructed or has been financed and is in the process of being constructed.

Based on the model and our calculations, we estimate that the total positive impact of electricity from nuclear power facilities and CANDU exports on Canada's GDP from 1962 to 1992 was approximately $23 billion.

It should be noted that this estimate does not reflect the significant research and development activity that is also carried out by the Canadian nuclear industry.

Direct Employment

A substantial base of high technology knowledge and jobs exists in Canada as a direct result of the nuclear industry. We estimate direct employment in the nuclear industry at approximately 30,000 jobs in 1992. This represents a 9% increase in employment over the past three years. Our survey results suggest that approximately 90% of these jobs are full-time. Part-time employees work an average of 35-40% of their time on nuclear-related activities. In 1992, Darlington Nuclear Station represented the only construction jobs in Canada associated with major capital projects in the nuclear sector. Employment associated with refurbishing and/or maintenance of CANDU reactors is reflected in the private sector suppliers' employment numbers.

Based on ISC estimates, direct employment in the nuclear industry would rise by an additional 1,000 direct jobs for each export reactor sold abroad. These estimates are based on signed contracts for Wolsong 3 and 4.

Direct jobs in the nuclear industry are associated with the production of reactor fuel, the manufacture of equipment, the operation of generating stations and heavy water production facilities, and the production of isotopes for use in medicine, industry or agriculture.

It is estimated that 3,200 scientists and engineers are currently employed in the nuclear industry. Of these, over 600 are in scientific, 2,300 in engineering and approximately 300 in management positions. Although the number of positions has decreased by 500 over the past ten years, it is predicted that the future requirements needed to sustain the existing nuclear facilities in Canada will prevent any rapid decline in numbers in this portion of the industry over the next fifteen years.

The employment impact can also be illustrated through assessing the comparative value of a nuclear facility and a coal facility drawing upon imported U.S. coal[44]. Exhibit 3.1 shows that a 2,000 MW nuclear facility, operating at 80% capacity, is estimated to provide 2.5 times as many Canadian jobs than would a coal facility (124,000 vs. 49,000). The model is based on a four-unit station located in Ontario only and also assumes that both plants would operate at the same capacity over a 40 year operating life.

Exhibit 3.1 - Coal-Fired versus Nuclear Plant - Estimated Employment (2,000 MW plant)

	Coal		Nuclear	
	(in person years)			
	Canadian	Other	Canadian	Other
Design and Construction	30,000	4,000	45,000	7,000
Operating, Maintenance, Admin.	16,500	-	52,000	-
Fuel Supply	-	197,000	27,000	-
Scrubbers (Limestone)	2,500	-	-	-
Sub-Totals	49,000	201,000	124,000	7,000
Total Jobs	**250,000**		**131,000**	
Canadian Content	**20%**		**95%**	

Source: CNA, 1993

Canadian jobs are also associated with CANDU export contracts, although these clearly depend on the degree of local content that the purchasing country wishes to obtain. With respect to CANDU project sales, the confirmed sale of two additional CANDU 6 reactors to South Korea is expected to result in more than $1.5 billion in new business in export revenues for equipment suppliers, engineering, architecture and project management firms during the construction lifetime of the entire 4-unit Wolsong project (1976 to 1999)[45].

[44] Ontario Hydro, a prime producer of nuclear energy, uses coal bought in the United States to generate 20% of its electricity supply. National Energy Board, 1991

[45] Source: AECL Press Release on Wolsong 3 and 4, 1992

Indirect Employment

In addition to direct employment of 30,000, we estimate that a minimum of 10,000 indirect jobs depend on the nuclear industry in Canada[46]. Indirect employment can be defined as the number of person years required to produce the commodities for all but the first stage of production. For example, it reflects the employment needed to manufacture the steel to be used at a later date to produce engineered components required for the construction/maintenance of a nuclear reactor.

Ten thousand jobs is a minimum estimate and holds true when no new reactors are being constructed. Based on analysis of the signed Wolsong 3 and 4 contracts, ISC estimates the domestic indirect employment multiplier to be 2.5 for the start-up of a new export reactor project. This means that indirect employment in Canada will rise by 2,500 jobs when each new CANDU export project is undertaken.

Induced employment was not calculated. Induced employment is that which is created through the spending of disposable income. However, jobs in the Canadian economy do depend on the purchases made by the employees of the nuclear industry when they spend their pay cheques.

Sales

In 1993, Canada accounts for 7% of the world's market share of nuclear reactors and 10% of market share of nuclear reactors under construction. The twin reactor order from South Korea, valued at over $1.0 billion, was Canada's largest single export order in 1992[47].

Private sector sales include revenues from mining and refining of uranium, R&D, engineering & design, manufacturing, construction, operation and maintenance services and other. Our survey data show that private sector suppliers have generated total sales estimated at $9.4 billion between 1989 and 1993. Compared to sales of $350 million in 1977, this represents a

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[46]This estimate has been verified with Statistics Canada and ISTC, Electrical and Energy Equipment Branch, 1993.

[47]Energy Council of Canada, 1993.

compounded growth rate of approximately 23% annually. In real terms, it represents a 17% compounded annual growth rate.

At present the split between domestic and export sales is 60%/40%, respectively. In the future, the industry expects this split to reverse, with exports accounting for 60% of total sales and domestic sales accounting for 40%.

Tax Revenues

On the basis of our survey and subsequent analysis, we estimate that the federal government receives approximately $700 million in tax revenues annually from the nuclear industry in the form of income and sales taxes. This figure excludes corporate taxes. Corporate taxes are not included because their calculation would be unreliable guess-estimates at best. Nuclear activities comprise a small percentage of the activities undertaken by most suppliers and it would be difficult to apportion corporate taxes to the percentage of a supplier's nuclear-related business.

All tax revenues estimates were calculated using Statistics Canada's Open Output Determination Model.

Foreign Exchange Savings or Positive Contribution to the Current Account Deficit

From 1965 to 1989, nuclear energy saved the Canadian economy approximately $17 billion[48] (1989 dollars) in foreign exchange. Ontario Hydro estimates that $14.5 billion of this $17 billion would have been spent on importing coal from the United States to Ontario and $2.5 billion on some other forms of energy. It also estimates that, in the 1990s, foreign exchange savings will amount to approximately $1 billion a year.

In addition to averted coal imports, nuclear capability has also helped Quebec and the Atlantic provinces avert oil imports. For example, much of the Atlantic region relies upon imported oil and it is estimated that the Point

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48 Interview with Ontario Hydro, 1993

Lepreau installation averted $1.1 billion worth of oil imports from 1983 to 1988 and by 1993 savings had probably risen to over $2 billion[49].

Exports

Annual exports of nuclear products and services in 1991 were approximately $550 million. This comprised:

- Uranium exports = $290 million
- AECL exports = $100 million
- Other exports (i.e. Theratronics) = $100 million
- Nuclear electricity exports by the utilities = $61 million

Positive Trade Balance

Canada's nuclear industry has a positive trade balance because imports constitute a very small portion of the nuclear industry's inputs. Specifically, the nuclear industry imports approximately $50 million worth of specialized equipment each year and special metals and alloys like zirconium for use as fuel bundle cladding or sheathing materials.

Estimates of the size of the positive trade balance vary. Using the figures referred to above and subtracting imports of approximately $50 million, our study estimates that the nuclear industry in 1991 generated a positive trade balance of $500 million.

Based on its definition of the high technology components of the nuclear industry, Industry and Science Canada estimated that the nuclear industry generated a trade surplus of $250 million in 1991. As shown in Exhibit 3.2 nuclear and aerospace were the only high-technology sectors with a positive trade balance in 1991[50].

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49 Source: Manager of Point Lepreau; quoted in Newspaper article, La Tribune, April 1988.
50 Electrical and Energy Equipment Branch, ISC,1992

Exhibit 3.2- Canada's High-Technology Trade Balance, 1991

Industry	$Millions
Aerospace	$950
Nuclear	**$250**
Biotechnology	($60)
Opto-electronics	($190)
Weapons	($280)
Material Design	($500)
Computers and Telecommunications	($3800)
Computer Integrated Manufacturing	($1300)
Electronics	($1500)
Life Sciences	($1900)

Source: Industry and Science Canada, 1992

To provide these estimates of high technology trade for Canada, Industry and Science Canada decided to use a list of advanced technology products developed by the U.S. Bureau of the Census[51]. However, among the exports defined as high-tech by the Bureau of the Census is natural uranium oxide, which has the lion's share (98%) of the nuclear positive trade balance. The remainder consists of nuclear reactors, or parts of, and instrumentation, fuel elements and other special uranium compounds.

As indicated in Exhibit 3.3, Canada gained $228 million[52] in 1991 in annual foreign exchange revenues through the sale of uranium internationally.

Exhibit 3.3 - Canada's Uranium Trade Balance ($ million)

	1987	1988	1989	1990	1991
Exports	886	585	456	315	290
Imports	18	75	109	105	62
Balance	$868	$510	$347	$210	$228

Source: Statistics Canada, 1991

Canada is the largest producer of uranium in the world[53] accounting for 40% of the Western world's production in 1992. In the late-1980s, the

[51] Trade in APT's S&T, Economic Analysis Division, ISC, 1992
[52] Statistics Canada, 1991
[53] EMR, News Release, Uranium Division, Electricity Branch, 1992

value of uranium exports was far greater than $228 million per year. An excess capacity of electricity in the world as well as the recent flooding of the uranium market by the former Soviet Union combined for a significant drop in the price of uranium on the world exchanges.

Maintaining Canadian expertise in uranium mining, refining and handling requires an ongoing investment by the mining industry. In 1991, the annual investment was approximately $66 million, although it has surpassed this level in previous years ($277 million in 1980, $160 million in 1985, and $138 million in 1990[54]).

Electricity Exports

Nuclear energy constitutes approximately 10% of total electricity exports to the United States. Exhibit 3.4 indicates that Canada exported over 2,000 gigawatt-hours of nuclear generated electricity in 1991 valued at $61 million[55]. In 1992, the export of Canadian nuclear generated electricity was reduced to approximately 1,300 GWh.

Exhibit 3.4 - Canadian Nuclear Electricity Exports, 1986-1991

Year	Total Electricity Exports GWh	Nuclear Exports GWh	Nuclear Exports Percentage
1986	35,271	2,484	7%
1987	45,359	2,041	5%
1988	29,729	2,151	7%
1989	18,462	2,032	11%
1990	16,944	2,054	12%
1991	19,828	2,172	11%
1992	26,244	1,312	5%

Source: Electric Power in Canada, Energy, Mines and Resources, 1991 and Natural Resources, 1992.

[54] Source: Uranium in Canada. Assessment of Supply and Requirements. EMR. September 1991.
[55] Electric Power in Canada, Energy, Mines and Resources Canada. 1991. Total Canadian electricity exports were $554 million in 1991.

Electricity Cost Savings

For Ontario, in 1992, nuclear power was 0.2 cents/kWh cheaper than fossil-fueled power. This cost advantage was largely driven by the lower cost of nuclear fuel. The cost differential for having used nuclear energy to generate electricity instead of a fossil fuel or hydraulic power is estimated to have saved Ontario consumers $5 billion in electricity costs up to the present date. These savings are in addition to the foreign exchange savings calculated above. Nevertheless, the relative cost advantage of nuclear has decreased since 1987.

Exhibit 3.5 - Average Costs of Electricity in Ontario, (cents per kilowatt hour)

	Total Costs				1992 Breakdown Costs		
	1987	1990	1991	1992	OMA	Fuel	D&F
Hydraulic	1.0	1.0	1.1	1.1	0.28	0.32	0.45
Nuclear	3.2	4.2	4.3	4.8	1.23	0.52	3.01
Fossil	4.0	4.6	4.7	5.0	0.96	2.43	1.65

Sources: Ontario Hydro Annual Reports, 1992

Available information indicates that, at the present time, hydro-electric power is the most cost-efficient source of energy in Ontario. Exhibit 3.5 indicates that its total cost is approximately one-quarter that of nuclear, and that it is lower in each of the Operation, Maintenance and Administration (OMA); Fuel purchase, storage and disposal; and Depreciation and Financing (D&F) categories. However, most of the commercially viable hydro-electric sites have been exploited and the capital investment for their construction has depreciated considerably by now. Consequently, in the absence of nuclear generation, new electricity requirements would have had to be mostly met by higher-cost fossil fuel generation.

Regional Development Benefits

The nuclear industry has generated regional industrial benefits by supporting the activities of more than 150 private companies across Canada. These companies supply nuclear-related products and services to AECL's main facilities in Ontario and Manitoba and the provincial utilities who are responsible for the operation and maintenance of nuclear facilities in Canada. Fifty-eight percent of these companies are based in Ontario, 14% in Alberta and 12% in Quebec. The remainder of the companies are located in other provinces. Sixty-six percent of these companies are in manufacturing, 30% in engineering and design and 16% in R&D.

A quarter of the 154 companies in the nuclear industry are new entrants, i.e., they started supplying the nuclear industry in the last ten years. In terms of percentage growth, New Brunswick has seen a doubling of suppliers in the last 15 years (albeit from a small base), Quebec has experienced a growth of 22%, Ontario has seen an 18% growth and Alberta has grown by 14%. At this time, Newfoundland, PEI, Manitoba and Nova Scotia have few, if any, suppliers to the nuclear industry.

New Brunswick and Manitoba offer particularly good examples of provinces gaining industrial benefits from the nuclear industry[56]. New Brunswick draws a substantial portion of its electricity supply from the Point Lepreau reactor. Benefits associated with this reactor are many - and it is a result of these advantages that nuclear activities represent one of the two main high-technology pursuits in New Brunswick (along with the frigate construction program at Saint John Shipbuilding). Some of these benefits include:

- NB Power is currently providing a training program for 100 Romanian operating and maintenance staff who will operate the CANDU plants in their country. The utility has also proposed to train the South Koreans who will operate the three new CANDU 6 reactors. Such training draws upon the highly qualified staff at NB Power and the CANDU 6 training simulator located at Point Lepreau.

- Twenty-five employees from the Point Lepreau facility are currently in Romania helping AECL commission the Cernavoda units.

- Maritime Nuclear, a division of AECL CANDU located in Fredericton, has established itself as a "Centre of Excellence" for power plant control systems. The staff draws largely upon the graduating

[56] Media Facts, New Brunswick, February 1992

contingent of the engineering faculty of the University of New Brunswick (UNB). Maritime Nuclear recently secured a $4 million contract to develop and construct a reactor monitoring system.

- AECL and UNB have joined, with the help of NB Power, to establish the Centre for Nuclear Engineering Research (CNER) at UNB. Recently, AECL shifted six scientists to Fredericton to work on a $1.25 million contract awarded to CNER[57].

- A decision to proceed with a second unit at Point Lepreau would generate an estimated 5,000 person-years of employment and $400 million worth of local benefit, while also further enhancing technical capabilities in the province.

The regional benefits from the activities conducted at AECL's facilities in Ontario and other provinces were not included in the scope of this study. However, a 1992 study of the economic effects of AECL's Whiteshell Laboratories on Manitoba[58] notes the following:

- AECL's facility in the province supports 1,752 direct and indirect full-time jobs. These jobs in turn created tax revenues estimated at $34.9 million in 1991.

- For each one dollar expended by AECL, 85.5 cents were spent in Manitoba.

- AECL expenditures in Manitoba in 1990/91 increased the province's GDP by $93.1 million.

- Each one dollar in direct expenditures that AECL makes in Manitoba raises the province's GDP at market prices by an estimated $1.19.

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[57] Media Facts, New Brunswick, February 1992

[58] "AECL Economic Impact Assessment" 1992, A Study prepared by the Manitoba Bureau of Statistics. Wilf Falk, Director.

3.2 Related "Spin-off" Benefits

The research conducted by AECL and others in the Canadian nuclear community has led to the development of new products and technologies. Some of the more important ones are discussed below.

3.2.1 Cobalt-60 - Medical and Industrial Benefits

Canada is a world leader in the production of this valuable isotope, supplying over 80 percent of the world's total Cobalt-60 used in medical and industrial applications[59]. Cobalt-60 for medical uses is produced in the NRU reactor at AECL's Chalk River Laboratories, while the Cobalt-60 used in industrial applications is obtained from CANDU reactors.

Cancer Treatment and Medical Diagnosis

AECL was instrumental in the development of Cobalt-60 treatment of cancer. This is perhaps one of the most important developments of the Canadian nuclear program.

Cobalt-60 is a man-made radioisotope produced using a nuclear reactor. The product is the most widely used radioactive isotope in cancer treatment. Cobalt-60 has been in active medical use treating cancer patients since the 1950s.

In addition, over 1,300 of the world's cobalt therapy machines have been supplied by Canada. This figure represents close to 50% of the total Cobalt-60 therapy machines being used to date.[60] Every year in 70 countries, an estimated one-half million people are treated for cancer using cobalt therapy machines designed and built by Theratronics (formerly the Medical Products Division of AECL).

Another major benefit is the use of radioisotopes to help diagnose medical ailments and prescribe remedies. Such isotopes can detect how well organs are functioning, how well the body absorbs particular substances, where tumors might be located, and a range of other valuable uses. Nordion estimates that approximately 7 million people benefit from the isotopes

[59] Nuclear Fact Sheets, The Canadian Nuclear Association, 1992
[60] Ibid, 1992

every year . Molybdenum 99, produced at Chalk River, has been used in more than 50 million medical diagnostic procedures since 1977/78[61]. While precise financial calculations are elusive, it should be noted that the use of radioactive isotopes in nuclear medicine has produced uncounted savings through the avoidance of otherwise necessary exploratory surgery.

Sterilization

In addition to cancer treatment, Cobalt-60 is also widely used in the sterilization of medical and surgical equipment. The process of irradiation kills bacteria and other organisms and it is most effective as a sterilizer of heat sensitive materials such as plastics, ointments and solutions. Approximately 30 percent of all disposable medical supplies used in the world are sterilized by Cobalt-60 produced in Canadian reactors[62].

AECL engineers developed the first commercial sterilizers in 1964 - there are roughly 170 such units in use currently in 46 countries, of which 90 are Nordion designs.

Applications for this irradiation technology are potentially vast and include food, cosmetics, pulp and paper, and human waste treatments. The use of radiation to destroy micro-organisms found in sewage sludge could represent a partial solution to burgeoning landfill space problems.

3.2.2 Other Commercial Spin-Offs

Other spin-offs include products that are closely linked to AECL's technologies such as reactor concepts, waste management and accelerator development and are being sold by AECL. Since 1990, inventions from AECL have twice been recognized by R&D Magazine as being among the 100 most significant new technical products of the year (the IMPELA and the APUCOT).

To date, two IMPELA accelerators, each worth $4.8 million, have been sold and will be used for sterilization of medical products and for irradiation of materials.

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61 AECL Research, 1993

62 Ibid, 1992

In addition, other products/businesses have been spun out as a result of R&D conducted at AECL and are being further developed and sold by independent companies. Examples of such businesses include the following:

- Bubble Technologies Industries (BTI) has developed a unique radiation detector incorporating a liquid which produces bubbles when exposed to radiation. The stronger the radiation, the more it bubbles. Sixteen people are employed by this company in the village of Chalk River.

- Delta Temax (formerly EXOTEMP) used AECL-developed technology to manufacture micro-climate systems, which extend human performance in extreme heat temperature environments by actively cooling the body. This technology was used by Canadian helicopter pilots during the Gulf War. The Ministry of Defense in the United Kingdom also signed significant contracts with Delta Temax. The Pembroke, Ontario-based company employs 14 staff.

- Until 1991, SENSYS, was an AECL business unit dedicated to developing specialized sensing and measuring instruments that measure the condition of equipment. It is now owned and operated by GasTOPS Ltd., specializing in gas turbine engine performance monitoring.

As well, there are many non-nuclear applications of AECL technologies in service and R&D contracting. Three examples are listed below:

- AECL sealant technology has been extended outside the nuclear industry, principally in the contribution made to the design of the seals for the U.S. Space Shuttle Rocket Booster and Advanced Solid Rocket Motor under contract from Morton Thickol Inc. This work has earned revenues of approximately $5 million since the start of AECL's involvement following the Challenger disaster in 1986.

- Neutron radiography of turbine blades at Chalk River has earned yearly revenues of over $500,000 and made a significant contribution to the quality of Canadian-made aircraft engines.

- AECL expertise in vibration technology is contributing to safety and efficiency in the hard-rock mining industry through the development of loose-rock detection methods and improvements to mining tools. Revenues of over $2 million are estimated for 1992-1994.

3.3 Environmental, Agricultural and Other Benefits

3.3.1 Environmental Benefits

No Contribution to Global Warming and Averted Acid Rain

Nuclear energy is a clean form of energy, particularly in comparison to thermal sources such as coal and oil where the fossil fuel is burned to create steam and energy. Because there is no combustion during the nuclear reaction, nuclear energy does not emit acid gases or carbon dioxide (CO_2)[63].

The total lifetime production of energy from CANDU reactors in Canada is over one billion MWh up to 1992. Given that one tonne of coal generates the equivalent of approximately 3 MWh, one-third of a billion tonnes of coal would have been required to replace the energy furnished by nuclear sources. This in turn would have contributed to the emission of approximately 800 million tonnes of CO_2, 80 million tonnes of ash, and 32 million tonnes of sulfur dioxide (SO_2) during the past 25 years[64]. A recent study by the Ontario Ministry of Energy[65] estimated that provincial CO_2 emissions decreased by around 7 percent due to the nuclear capacity at the Pickering B and Bruce B generating stations.

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63 The statement is confirmed by an Ontario Ministry of Energy Paper on greenhouse gas emissions and global warming entitled "Tracking Progress to Deal with Global Wanning-An Ontario Perspective", 1992.

64 CNA, estimates, 1993

65 "Tracking Progress to Deal with Global Warming-An Ontario Perspective", Ministry of Energy 1992.

Exhibit 3.6 - Annual Emissions: Coal versus Nuclear (Station producing 1,000 Megawatts)[66]

	Coal		Nuclear
Power	1,000 MW station		1,000 MW station
Land use	70 hectares		20 hectares
Waste			
Ash (000 tonnes)	600	Used Fuel	0.1
CO_2 (000 tonnes)	6000	Uranium Tailings	25
SO_2 (000 tonnes)	100		
NO (000 tonnes)	16		

As indicated in Exhibit 3.6, annual emissions of 6 million tonnes of greenhouse gas (CO_2), 100 thousand tonnes of acid gas (SO_2) and 16,000 tonnes of the acid gas nitrogen oxide (NO) are associated with the operation of a one gigawatt coal-fired power generator. These emissions contribute directly to the world's global warming and acid rain problems. No significant volumes of any of these emissions are associated with nuclear power. In New Brunswick, for instance, it is estimated by NB Power officials that the Point Lepreau reactor averted the release of 310 thousand tonnes of SO_2 between 1983 and 1986.

Evidence supporting the minimal environmental impact of nuclear generated power was brought forward by Mr. Jean Dàniel Levy, of Direction générale de l'énergie in France, during the 1989 World Energy Conference. Between 1980 and 1988, 90% of electricity generation in France was provided by energies that do not contribute to the greenhouse effect (70% nuclear and 20% hydro). During the same time, France has reduced CO_2 emissions by more than 35% while increasing real economic activity by 10%. In 1989, France had one of the lowest levels of CO_2 emissions per person-year among industrialized countries[67].

It is also worth noting that burning other fossil fuels also generates gases that are damaging to the environment. As indicated in Exhibit 3.7, natural

[66] Canadian Nuclear Industry Fact Sheets, 1992

[67] World Energy Conference, Round Table Five: "What Should We Do Now About the Greenhouse Effect?" 14th Congress, Montreal, 1989

gas, oil and fuel wood, when burned, are major emitting sources of global warming gases.

Exhibit 3.7 - Annual Carbon Dioxide Emissions in Canada[68]

	Million Tonnes
Natural Gas	140
Coal	85
Gasoline	80
Diesel Oil	45
Fuel Wood	25
Aviation Fuel	10
Coke	10
Nuclear	0

Source: Environment Canada, 1990

Scrubbers and Sludge

The requirement to install scrubbers and other technologies to address fossil burning related emissions is another factor to enter into this equation (at an estimated cost in Ontario alone of $2.5 billion between 1990 and 2000, according to Ontario Hydro).

Utilities that choose to scrub then face the dilemma of where to put the resultant sludge. Some of this by-product can be sold commercially, but an acceptable sludge disposal method must be found.

> ...Whether the developers of energy policy in Canada seek to limit carbon emissions by means of quotas, or by tradeable permits, the pressure will be generated to develop cost-effective methods of carbon disposal-a requirement that has never applied in the past. The current options include (deep) ocean disposal, aquifer disposal and biological disposal, but there is no front-runner or bench-mark technology at the present moment[69].

68 Environment Canada, 1992

69 Cockshutt, E. Philip, Executive Director, Energy Council of Canada -Energy The New Realities, 1993

Health Hazards from Air Pollution

The health hazards associated with air pollutants from burning fossil fuel have been estimated by Havard and MIT Researchers. In 1980, they estimated that over 50,000 annual deaths in the United States were attributable to the negative health impacts of air pollution.[70]

Saved Land Use

Nuclear energy uses less land than any other commercial form of energy production. The land use advantage of nuclear over coal stations was shown in Exhibit 3.6. In contrast, as illustrated in Exhibit 3.8, the hydro-electric option requires up to 15,000 square kilometres for its complexes because of the large-scale flooding of land.

The land-use comparison is further illustrated by the fact that the Bruce A generating station is more than equivalent to a Hibernia-size oil development in terms of lifetime energy production[71] while the 16 units at the Pickering and Bruce stations together are equivalent in power output to the massive James Bay project.

While renewable energy sources are appealing alternatives to nuclear energy, it is not evident (aside from hydraulic power) that such energy can be generated with sufficient reliability, economy or volume to provide any meaningful level of support to the national economy. For example, to produce the electricity needed to power a city such as Toronto, wind energy generators would require a land mass four times the area of Prince Edward Island, or 23,000 square kilometres. This would require 40,000 wind generators on towers over 100 feet high, each producing substantial noise and visual pollution. Backup generators would also be essential to compensate for periods of insufficient wind velocity. By contrast, the Pickering nuclear station occupies two square kilometres of land surrounded by a one kilometre radius exclusion zone. This represents the

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70Wilson, Colome, Spengler and Wilson, Health Effects of Fossil Fuel Burning-Assessment and Mitigation, 1980.

71AECL, Energy Strategies for Our Future, 1992 total land mass needed to generate sufficient energy to supply more than the city of Toronto[72].

Societal Impacts of Various Forms of Energy.

Exhibit 3.8 also illustrates the relative advantages of nuclear over other sources of energy. It shows that the nuclear option accounts for one of the lowest lost days of life expectancy, the lowest land use and the lowest CO_2 emissions compared to all the other conventional and non-conventional energy sources examined.

Again, as discussed earlier, one of the major challenges facing the nuclear industry, is high-level nuclear waste management.

3.3.2 Agricultural Benefits

Insect Control

In addition to direct treatment of food, irradiation is also used to sterilize insects. Reproduction diminishes when sterile insects are released back into the insect population.

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72 CNA, Fact Sheets, 1992

EXHIBIT 3.8 **Energy Options: Societal Impacts - Based on 37 Countries**

Option Supplying 40 GW of Energy	Safety Impact: Loss of Life Expectancy Days (a)	Safety Impact: Gain of Life Expectancy Days (c)	Land Use km^2	CO^2 Tonnes per GW (EU) per Year (b)	Basic Problems (Manageable Problems)
Solar - Photovoltaic	< 1 (k)	62	630	600 (f)	Cost, Unreliability, Land Use
Biomass - Wood Plantation	3.5	62	25,600	600(f)	Cost, Land Use, (Air Pollution) (h)
Windmills	< 1 (k)	62	9,900 (g)	600(f)	Cost, Unreliability Noise, Unsightliness
Hydro-electric	2.3	62	(200 - 15000) (j)	2,000 (f)	Land Use, Unsightliness, Limited Resources (i)
Oil	4.5	62	20	700,000	Greenhouse, Depletion (h)
Natural Gas	0.8	62	20	400,000	Greenhouse, Depletion (h)
Coal - Power Stations	8.4	62	30 - 40	900,000	Greenhouse, (Air Pollution) (Dirt) (h)
Nuclear	0.8	62	10	2,400	Radioactivity (h)
20% Reduction of End Use Electrical Energy Supply	62 (d)	≤ 8.4 (e)	Reduction (e)	Probable Reduction (e)	Reduction of Economic Activity (Employment, Personal Income, Taxation Yield)

(a) *Risks are calculated on a full basis, taking into account all phases of construction, operation and maintenance of the system.*

(b) *CO_2 from production of construction materials is spread over the life of the plant.*

(c) *Estimated fractional contribution of the energy component to the gain of life expectancy observed in advanced industrial societies.*

(d) *Assessed consequence of energy shortage.*

(e) *Reduction in detrimental impacts depends on the kinds of base energy which are reduced.*

(f) *Depends greatly on mix of steel, aluminum and concrete and the source of energy for manufacturing sources.*

(g) *Territory overshadowed by large windmills; most land can be used for other purposes.*

(h) *Unsightliness is not listed for these cases because the power stations are very compact.*

(i) *Deep draw-down in lakes can result in unpleasant shore zones and mud flats, usually at the height of the recreational season. Mercury mobility is assumed to be short-lived and manageable.*

(j) *Site Specific considerations dominate. Wide range indicated is illustrative of small and large-scale hydro developments.*

(k) *Since the alternative energy systems have not yet been established on a large scale (i.e. contribution to national electricity production is less than 1% of total electricity production), the risk data for those systems have large uncertainties and are therefore considered as preliminary. The Loss of Life Expectancy for those technologies can be considered negligible.*

Source: Energy for 300 years, Institute for Risk Research of the University of Waterloo, 1992

Improving Livestock Productivity

Radioisotopes are used to improve the nutritional characteristics of feed for livestock and to gauge optimal hormone levels and breeding times. The combined results are more productive and disease-resistant livestock.

Soil Fertility and Irrigation

Another agricultural benefit is the use of nuclear techniques to detect and track fertilizer-supplied soil nutrients such as nitrogen and phosphates. This technique helps in determining the efficiency of fertilizer utilization and in reducing fertilizer costs and polluting emissions.

Food Irradiation

Canada has 40 years[73] of research experience in the field of food irradiation. Nordion (formerly a division of AECL and now owned by MDS Health Group) is a world leader in this technology which offers substantial food and health benefits.

When food is passed through an irradiation chamber microbial cells, such as bacteria, yeast and moulds are broken down. Parasites, insects or their eggs and larvae are either killed or made sterile.

Food irradiation holds great promise in the control of food-borne diseases such as salmonellosis. It can also extend the shelf-life of many foodstuffs (particularly grains, fruits and vegetables) at competitive costs while offering an alternative to the use of fumigants and chemicals, many of which leave residues.

Despite public misconceptions, recent reviews by the World Health Organization[74] and many others have again confirmed that the irradiation process is safe and that it does not decrease the nutritional value of food. In fact, irradiated food is often safer to consume than non-irradiated food.

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[73] Globe '92, Food Agriculture and Fisheries, AECL Issue Briefs, 1992

[74] World Health Organization special panel finding. The panel undertook a comprehensive review of all published and unpublished data to-date, 1992.

The potential benefits of using food irradiation technology are vast. One-third of the world's crop production is lost through spoilage after harvest[75] and can be reduced by the application of this technology.

3.3.3 Other Benefits

Proximity to Urban Centres

Nuclear and fossil fuel facilities can be located in optimal locations whereas hydro-electric facilities must be located where dictated by nature (and in a way which can disrupt nature). For example, according to Ontario Hydro, Ontario's untapped hydro-electric potential is ostensibly 12.4 GW of power or almost two-thirds of the existing hydro-electric base. However, most of this lies in the far north. The ability to locate nuclear plants nearer to urban centers provides a substantial reduction in the need for space-consuming and costly transmission lines and their attendant power losses.

Worker Safety

Exhibit 3.9, below, describes worker safety associated with energy production in Ontario over the ten-year period from 1978 to 1987. The information is sourced from Ontario Hydro - an operator of the three types of facilities compared.

Exhibit 3.9 - Worker Safety and Various Energy Forms (Ontario, 1978 - 1987)

	Fatalities per 100 million hours	Permanent Disabilities per 10 million hours	Temporary Disabilities per million hours
Nuclear	0	1.4	2.1
Fossil	2.7	0	8.1
Hydraulic	12.0	1.8	6.3
All Manufacturing	2.5	16.4	32.7

As indicated, nuclear energy provides the safest worker environment of any of the three energy forms and its level of temporary disabilities is lower than those of the manufacturing sector by fifteen-fold. The fatality rate for

[75] Ibid, 1992

nuclear plant operation is zero (no station staff have died). Furthermore, according to the AECB Advisory Committee on Nuclear Safety,

> A critical review (was) made of recent evaluations of the risks of fatalities, occupational and public, from three systems for the production of electricity: coal, nuclear, and hydraulic...
>
> It is difficult to make an unequivocal comparison of the risks of occupational and public fatalities amongst the different electrical energy systems studied. For normal operation, the data indicate that occupational risks in the coal fuel cycle are significantly higher (2 to 4 times) than those in the nuclear and hydraulic systems. The results also suggest that coal-fired (and oil-fired) systems present greater risks to the public than do nuclear and hydraulic systems.
>
> The risks of public and occupational fatalities from catastrophic accidents are very low for all the technologies assessed in this report, and furthermore are probably lower in Canada than in the world at large. The risks of fatalities from catastrophic accidents in CANDU systems appear to be lower than those in the LWR (U.S. light water reactor) systems[76].

It should be noted that employees have died of non-radialogical causes during the construction of nuclear plants. No evidence exists to suggest that workers at nuclear facilities are more prone to cancer than are members of the general public.

A study has been under way since 1980 on the mortality of past and present AECL employees. The study population consists of 13,491 persons, 9,997 males and 3,494 females, for a total of 262,403.5 person-years at risk.

[76] Alternative Electrical Energy Systems - A Comparison of the Risks of Occupational and Public Fatalities. Advisory Committee on Nuclear Safety. AECB 1989

During the period 1950-1985, 1,299 deaths occurred in this population. The number of female deaths (121) is too few for detailed analysis, but the 1,178 deaths in the male population represent a useful basis for this study.

The observed mortality among AECL employees from all cancers and from all non-cancers is less than expected in the general Canadian population. No statistically significant increase from any individual cancer cause of death was seen in the study[77].

Increased Quality Standards in Non-Nuclear Areas

A number of companies surveyed mentioned the benefits of meeting the high quality standards demanded by AECL and the provincial utilities in sourcing supplies and services for nuclear reactors. The view of these firms is that by meeting the stringent nuclear standards, their firms then produce higher quality products in other fields. For example, Velan Valves, a Quebec based company, is a world-leader in terms of the quality of valves it produces. They supply the nuclear industry and a range of non-nuclear industries that also require high quality products that can meet demanding standards. Velan attributes much of this success to its nuclear business. We profile Velan Valves and other companies in our case studies section which follows.

[77]Source: A Study of the Mortality of AECL Employees. AECL; September 1992.

Section Four: Case Studies of Successful Companies[78]

This section presents five detailed examples illustrating how nuclear energy and nuclear science have brought particular benefits to individual companies across the country. These case studies are drawn from a long list of candidates - for every organization profiled here, there are several more that could have been.

1. Babcock & Wilcox

Background

Based in Cambridge, Ontario, Babcock & Wilcox (B&W) International is Canada's largest producer of steam generators. B&W first began operating in 1844 on the shores of Lake Ontario as a foundry. Since then, the firm has diversified and expanded its line of business as well as its customer base. B&W's yearly bookings are in the $600 million to $800 million range. It is now a division of McDermott International, a multinational corporation specializing in energy-related technologies.

B&W products include a complete line of steam generating systems for the coal, oil, gas and nuclear energy sectors. During the past thirty years B&W has specialized in manufacturing new and replacement steam generators for the nuclear industry and CANDU reactors. Since the 1950s, B&W has provided 205 nuclear steam generators for Ontario Hydro as well as generators for Hydro-Quebec, the New Brunswick Power Corporation, and for plants sold by AECL to Argentina, Romania and South Korea. B&W's line of nuclear plant components includes CANDU moderators, heat exchangers, pressure vessels and shutdown coolers. In services, B&W has repair and maintenance contracts for chemical cleaning and tube water lancing.

78 These case studies are based on a review of pertinent documents and interviews with officials of the companies profiled. All companies had the opportunity to review/revise the write-ups.

Successes

The expertise gained from business within the Canadian nuclear industry has placed B&W at the forefront of the nuclear steam generator market. As a result, the firm is also active in the United States and other international markets. In 1992, B&W won 70% or 14 of the replacement steam generation contracts awarded in the U.S., all of which were in <u>non-CANDU</u> reactor units. In total, these contracts are valued at $300 million. In capturing this work, B&W competed against teams led by Westinghouse and Siemens. These contracts involve over one million manufacturing hours and will increase B&Ws nuclear-related sales from $40 million in 1992 to an estimated $375 million in 1993. Overall, these contracts have allowed B&W to increase its total capital budget from $1 million to $12 million between 1992 and 1993 and to hire an additional 50 engineers to support the design and manufacturing of the replacement steam generators.

The high standards and safety specifications required by the nuclear industry have enabled B&W to achieve a competitive advantage in technological design and engineering. This reputation for quality products and services provides an edge in supplying non-nuclear power equipment to other domestic and foreign industries.

Maintenance is expected to represent a substantial domestic growth sector in coming years as the existing CANDU reactors are upkept and upgraded. In 1992, such work generated approximately $30 million worth of work for B&W. Research and development contracts also represent a growth area. B&W's own in-house nuclear research spending amounts to approximately $350,000 in 1993. Both maintenance and R&D contracts are important to B&W as the Canadian nuclear market is often cyclical, and dependent on the construction of new nuclear power plants.

2. Sulzer Bingham Pumps

Background

Located in Burnaby, British Columbia, Sulzer Bingham Pumps first began operations under the name of Bingham Pumps in 1965. Two years later, the firm expanded its facilities to accommodate a growing demand for industrial pumps. In 1974, a second addition was undertaken in order to install a primary heat transport pump test facility. This facility was needed to design, build and test the primary heat transport pumps for the CANDU 6 reactor. To support this activity, Bingham expanded its engineering capabilities and adopted the strategy of a Canadian entity serving the domestic and international markets. In 1988 the company was purchased by Sulzer, a Swiss conglomerate, and re-named Sulzer Bingham Pumps.

Successes

The primary business area for Sulzer Bingham Pumps is the construction and service of highly engineered pumps. These pumps are used in industries like pulp and paper, petrochemical and nuclear, which require the high volume but carefully controlled movement of liquids. For many years, the Canadian nuclear industry has provided major contracts to Sulzer Bingham to supply pumps for the CANDU reactors.

As a Sulzer Bingham Pumps executive stated, "The Canadian nuclear industry has provided us with the long-term viability to operate in Canada and abroad". Of the 125 employees, 25 are dedicated full time to serving the nuclear market. This number may increase as the company has recently secured contracts to manufacture pumps for the new South Korean CANDU 6 units. Exports currently account for some 70 percent of total sales.

Spin-offs

The quality standards required by the nuclear industry are the most stringent of any of Sulzer Bingham's customers. In response, the firm has adopted a policy of applying these standards to all pumps regardless of whether they are destined for nuclear or non-nuclear use. Although these above-par standards have resulted in relatively high product costs, the firm has a valuable reputation for high quality and durable products.

3. Velan Valves

Background

Velan is a Quebec-based company which designs, manufactures and markets steel valves in a broad range of types, sizes, uses and technologies. The firm began its involvement in the nuclear sector in 1958, providing about 8500 valves to an experimental fuel processing plant in the United States. During the 1960s, Velan valves were selected for 55 nuclear power plants as well as for all U.S. nuclear-powered aircraft carriers. In 1968, Velan became the first valve manufacturer to receive the American Society of Mechanical Engineers' "N" stamp authorization for nuclear equipment. This stamp ensures Velan abides to a specified code of standards required to sell products in the American nuclear market.

Successes

The company has three Canadian plants and is currently the North American leader in the steel valve market. Typical user markets include oil and petrochemical companies, pulp and paper firms, power utilities and shipbuilders. Thermal power plants currently represent an important market niche for Velan. Velan is a major supplier to the North American nuclear power industry, pioneering many leak-free valve designs for nuclear plants. Internationally, Velan is becoming the leading supplier of valves for nuclear plants, having outfitted 200 stations in 24 countries. All of the nuclear stations in France and South Korea, for example, use Velan valves.

Spin-offs

According to Velan executives, the quality standards required by the nuclear industry have assisted Velan to achieve a high level of quality for their entire product line. For example, in 1972, Velan developed a new generation of nuclear valves with improved safety and longer maintenance-free service life. Many of these designs were subsequently transferred to (and became standard for) all Velan valves used in critical applications.

In 1992, Velan's worldwide sales were $190 million. Of this total, about $25 million was to the nuclear sector. This proportion should be maintained over the next three years as the new South Korean contracts are filled.

4. Canatom

Background

CANATOM is Canada's largest privately owned engineering firm operating exclusively in the nuclear industry. During its twenty-six year history, it has been a key player in virtually all CANDU commercial developments. As part of the CANDU team, and in its many other endeavours, CANATOM has worked in twenty-five countries.

CANATOM's roots date back to the time when Pickering and Gentilly were being developed. In the 1960s Canada had major engineering firms with experience in various aspects of nuclear power:

- The Montreal Engineering Company (Monenco) worked with AECL on the Rapp project in India and with Canadian General Electric (CGE) on the Kanupp project in Pakistan.

- The Shawinigan Engineering Company played a leading role in working with AECL on the Canada-India Research Reactor project in the 1950s, on the construction of the Whiteshell Nuclear Research Laboratory and Organic Test reactor in the 1960s and with CGE on the Kanupp project in Pakistan.

- Surveyor, Nenniger & Chenevert (SNC) provided a wide range of engineering and management services for the Gentilly project.

In 1967, the three companies agreed to form a separate, jointly-owned engineering company to work exclusively in the nuclear field on an international scale. CANATOM is now equally owned by Monenco-AGRA Inc. and SNC-Lavalin Inc.

Successes

CANATOM established itself as a design engineering, procurement, project management and resident engineering company, on the strength of its work on a nuclear research reactor project in Taiwan and a heavy water reconstruction project in Glace Bay.

At the peak of its activity in the late-1970s, CANATOM employed 1250 highly skilled workers in Montreal and Toronto. During the early 1980s, CANATOM contracted with Ontario Hydro to design, install and commission a retro-fit emergency coolant injection system for the Pickering "A" station.

Spin-offs

The Canadian nuclear community faced slow periods during the 1980s, prompting CANATOM to explore other avenues. In the U.S. market, CANATOM found a profitable opportunity to draw upon its nuclear expertise and reputation.

The U.S. nuclear community differs from the Canadian scene in many respects. One of these is the predominance of privately owned utilities with a profit motive. While reactor safety falls within the purview of a national body, the financial regulation of private utilities is the responsibility of individual State Service Commissions. In bringing a new reactor into the rate base, States will often require a prudence audit to examine the management performance and practices of the utility in order to reconcile the differences between projected and actual construction cost and schedule.

CANATOM's competitive advantage in this market lay in it's worldwide reputation for engineering and management excellence and the fact that, not having close ties with utilities or commissions, it had a truly independent image. During the 1980s, CANATOM derived over $35 million in revenues from prudence audits and other services to American utilities and states. Developing relationships with U.S. utilities provided CANATOM with the opportunity to secure other nuclear engineering service work.

While U.S. revenues continued through the recession, there has been a revival of CANDU-related business resulting from the new sales to South Korea and the revived sale to Romania. CANATOM is providing concept and detailed design engineering, project management support and procurement, and training services for the three new Wolsong units, although Canadian input will diminish with each unit. CANATOM designed the reactor and service buildings for the Cernavoda plant in Romania and currently is providing construction management services for the project.

5. Theratronics International[79]

Background

Theratronics International Ltd. had its origins in Ottawa as the Commercial Products Division of Eldorado Nuclear, the uranium refining company that was owned by the federal government for a number of years. The Commercial Products Division of Eldorado Nuclear was transferred to Atomic Energy of Canada when the federal government established AECL.

At the Chalk River laboratories AECL scientists began to design commercial power reactors. The NRX, a powerful experimental research reactor, was first developed and followed by the NRU. Both units could also produce Cobalt-60, a radioisotope with great commercial potential.

Successes

Theratronics became a pioneer in radiation therapy through development of the world's first Cobalt-60 cancer treatment machine, unveiled in 1951. The

[79] This case study is based on a review of documents and a review by company officials.

treatment process was so effective that Theratronics became a market leader in radiation treatment and computer products used in cancer treatment .

In subsequent years, Theratronics built a solid international reputation. By 1991, sales had reached approximately $50 million, of which 85 percent was derived from export markets. In 1989 the federal government decided to separate Theratronics from AECL and privatize it. Although the Crown corporation has not yet been sold, revenues generated by Theratronics do not appear in the financial statements of AECL after 1990.

Section Five: Survey Results

5.1 Survey Process

A mail survey of companies who supply products and/or services to the nuclear industry in Canada was an important source of information for this study. Survey data were used to assess the economic impacts realized by the private sector suppliers and to obtain an understanding of the challenges and opportunities faced by the private sector.

The names and addresses of the supplier companies were obtained from the 1993 Yearbook of the Canadian Nuclear Association and the 1992 Directory of Companies in the Energy Sector from Energy, Mines and Resources. These sources include companies who have self-identified themselves as suppliers of products and/or services to the Canadian nuclear industry. Ernst & Young is confident that the 154 companies contacted represent the bulk of the private sector supply capability. A copy of the survey instrument is enclosed. Although 186 surveys were mailed out originally, follow-up telephone calls revealed that 12 companies no longer existed and 20 companies did not supply the nuclear industry.

The survey was designed to obtain the following types of information:

- A profile of suppliers in terms of their location by province, areas of business activity, years of operation, location of production facilities/offices, etc.;
- Types of products and/or services provided by Canadian suppliers;
- Performance of suppliers as measured by employment, domestic and foreign sales, incremental benefits of supplying to the nuclear industry (i.e., spin-offs, access to new markets, etc.);

- Factors affecting competitiveness in the nuclear industry in Canada; and
- Current challenges and future opportunities and threats.

The response status to the survey was as follows:

Exhibit 5.1 - Survey Response Status

Status	Number	Response rate %
Completed surveys	77	50
Unable to participate - time constraints	23	15
Declined to participate	12	7
No response	42	28
Total	154	100%

A detailed breakdown of the response rate by province is presented in Exhibit 5.2 below.

Exhibit 5.2 - Geographic Distribution of Suppliers

Location	Supplier Population	Percent of Population	Surveys Received	Response Rate %
British Columbia	3	2	1	33
Alberta	21	13.5	4	19
Saskatchewan	4	3	4	100
Ontario	89	58	50	56
Quebec	18	12	11	61
New Brunswick	4	2.5	4	100
United States	15	10	3	20
Total	154	100%	77	50%

Exhibit 5.2: Our survey sample adequately represents companies in Ontario, Quebec, New Brunswick and Saskatchewan and under-represents companies in Alberta and B.C. However, from a national perspective, we believe that the survey portrays a reliable picture of supplier activity in the

nuclear industry in Canada. This is because our respondents included all suppliers from New Brunswick and Saskatchewan, and at least half of the suppliers from Ontario and Quebec. As noted in the table above, some products and services are supplied by American companies.

The respondents included companies of varying size - in terms of sales and number of employees.

5.2 Summary of Key Survey Findings

The key findings of our survey are presented below in summary form.

Geographic Distribution of Supplier Companies

Today, there are over 154 companies who supply products and/or services to the nuclear industry in Canada. Fifty-eight percent of these companies are based in Ontario, 14% are based in Alberta and 12% in Quebec. The remainder of the companies are located across the country. Although a recent study[80] documents that approximately 90% of the nuclear suppliers who are based in Canada are owned by foreign companies, these companies provide direct economic benefits in terms of employment and tax revenue to the Canadian economy. Few Canadian industries benefit from avoiding globalization. Forty-seven percent of the domestic petroleum industry is Canadian owned, but only 39% can be classified as "Canadian controlled[81]".

Growth in the Number of Companies in the Last 10-15 years

One-quarter of the survey respondents are new entrants to the nuclear industry; i.e., they started supplying to the nuclear industry in the last ten years. The remainder have been in operation for the last 11-50 years.

Since the previous economic effect study conducted in 1978, it appears that New Brunswick has seen a 100% growth in suppliers (albeit from a small

[80] The Nuclear Industry in Canada: Ownership and Employment Trends, prepared by David Langille for The Coalition of Environmental Groups for a Sustainable Energy Future, 1992

[81] Based on upstream plus downstream revenues percentage. Canadian Energy Statistics, Natural Resources Canada, 1992.

base), Quebec's supplier base has grown 22% , Ontario has grown 18% and Alberta has increased 14%.

Areas of Activity - Types of Products and Services Supplied

Sixty-six percent of companies surveyed noted that they are involved in manufacturing activities, 29% are involved in engineering and design, 16% are involved in research and development and 12% are involved in operations and maintenance services.

Forty-eight percent of the companies surveyed supply only products to the nuclear industry, 13% supply only services and 39% supply both products and services. In general, individual companies often supply more than one type of product or service.

Capacity Utilization

There is significant excess capacity with respect to supplying the nuclear industry. Specifically, 62% of respondents from Ontario noted that they were under-utilizing their specialized equipment. Thirty percent of respondents from Quebec, 50% from New Brunswick, 50% from Saskatchewan and 25% from Alberta also noted the same.

With respect to personnel, the same magnitude of under-utilization was reported. However, it should be noted that the 1978 report on the impact of the nuclear industry in Canada also reported significant unused capacity by supplier companies.

Employment

The sixty-six companies that responded to this question reported a cumulative total of 5,206 employees working in nuclear-related activities. A majority of these employees are in Ontario. About 90% of employees are devoted full-time to nuclear-related activities. The 5,206 employees are paid total wages of $112 million annually. Thirty of these 43 companies reported spending a combined $87 million on training costs each year.

An extrapolation[82] of employment data to the population of 154 suppliers would suggest that approximately 8,500 full-time and part-time employees work for private sector suppliers.

Including these 8,500 private sector jobs, direct employment in the nuclear industry is distributed as follows:

Ontario Hydro	12,000	(Source: Interview with Ontario Hydro, 1992/1993)
Hydro-Quebec	650	(Source: Interview with Hydro-Quebec , 1992/1993)
NB Power Corp.	450	(Source: Interview, 1992/1993)
AECL	4,500	(Source: AECL Annual Report, 1993)
Private sector suppliers	8,500	(Source: Ernst & Young survey, 1993)
Uranium	2,200	(Source: EMR News Releases, 1992)
Public Sector Admin.	350	(Source: EMR News Releases, 1992)
Construction at Darlington	870	(Source: Interview with Ontario Hydro, 1993)
Other	350	(Source: EMR News Releases, 1992)
Total	30,000[83]	jobs (approximately)

A study by the Canadian Nuclear Association (1990) reported that total direct employment in the nuclear industry in 1990 was 27,520 jobs. Our analysis shows that the direct employment in the nuclear industry in 1993 has grown to approximately 30,000, a growth of about 9% over the three year period. Note that except for the construction at Darlington Nuclear Station, no major domestic capital projects were underway in 1992-93. Employment in activities such as refurbishing and maintenance of CANDU reactors are reflected in the employment figures for private sector suppliers.

82 We extrapolated survey numbers separately for separate sub-populations and then added the numbers. For example, we treated uranium companies and all other manufacturing and services companies as two distinct sub-populations. In some cases, we also divided companies by "Service" and "Manufacturing" if their survey responses were significantly different. This methodology ensures that the extrapolation is not exaggerated or under-stated. We believe that these extrapolations are reasonable given that half the companies from Quebec and Ontario responded to our survey and the respondents included companies of varying size - in terms of employees and total sales.

83 In earlier employment estimates, the employment of workers constructing nuclear facilities constituted a significant number. For example, previous reports suggested construction employment of 6400 in 1989 and 11,450 in 1977.

Total Sales

The 44 companies who responded to this question reported that over the five years between 1989 and 1993, their total sales amounted to approximately $3.5 billion, an average of approximately $700 million in sales annually. Based on our proportioned scaling we estimate the total sales of private sector suppliers as a whole at $9.4 billion for the last five years (1989 to 1993).

These figures represent an increase in nominal terms of 23% annually over the estimated sales volume of $350 million in 1977. In real terms, this represents an increase of 17% annually.

Respondents reported that the bulk of their exports were to South Korea followed by the United States and Romania. Other exports markets for the suppliers included Taiwan, Malaysia, Turkey and Argentina.

Survey respondents indicated that over the last five years, 60% of sales have been to the domestic market and 40% have been export sales. Nearly all respondents expect that over the next five years this proportion will reverse and export sales will comprise 60% of total sales.

Future Threats and Opportunities

Respondents identified the economic outlook (47%) and negative image (30%) as two key threats in the future. Difficulty in obtaining financing and lack of skilled human resources were also identified as potential future threats.

In terms of opportunities, 30% of the companies saw a positive demand outlook for nuclear products and services. This opportunity is complemented by forthcoming maintenance requirements in the industry, the popularity of CANDU reactors and the expected decommissioning of military and industrial establishments.

5.3 Detailed Survey Results

The following exhibits present a detailed breakdown of responses to each of the survey questions. The total percentages in the exhibits may not always add up to 100% because of rounding errors.

Exhibit 5.3: Location of Companies by Years of Operation

	BC	ALTA	SASK	ONT	QUE	NB	US	TOTAL	%
1 - 5 years	0	2	0	4	2	0	0	8	10
6 - 10 years	1	1	0	4	2	2	0	10	13
11 - 15 years	0	0	2	9	0	2	1	14	18
16 - 25 years	0	0	1	18	4	0	1	24	31
26 - 50 years	0	0	1	14	3	0	1	19	25
No Response	0	1	0	1	0	0	0	2	3
TOTAL	1	4	4	50	11	4	3	77	100%
PERCENT	1%	5%	5%	65%	14%	5%	4%	100%	

Exhibit 5.3: Of the survey respondents, 23% are new entrants to the nuclear industry, i.e., they started supplying to the nuclear industry in the last ten years. Seventy-seven percent of survey respondents have been in operation for the last 11-50 years.

Ontario, Quebec, Alberta and New Brunswick have seen the biggest increase in the number of new suppliers. Specifically, eight of the 18 new entrants are in Ontario and four are in Quebec, three in Alberta and two in New Brunswick.

Since the previous economic effect study conducted in 1978, it appears that New Brunswick has seen a 100% growth in suppliers (albeit from a small base), Quebec's supplier base has grown 22%, Ontario has grown 18% and Alberta has increased 14%.

Exhibit 5.4: Areas of Activity by Region

AREAS OF ACTIVITY	BC	ALTA	SASK	ONT	QUE	NB	US	Total	%
Mining and Refining of Uranium	0	1	3	1	0	0	0	5	6
Research and Development	1	0	0	9	0	1	1	12	16
Engineering and Design	1	0	0	15	3	2	1	22	29
Manufacturing	1	1	0	37	8	1	3	51	66
Construction	0	0	0	1	0	1	0	2	3
Operations/Maintenance Services	0	0	0	6	1	2	0	9	12
Transportation	0	0	1	0	0	0	0	1	1
Licensing/Startup Services	0	0	0	1	0	1	0	2	3
Software Development	0	1	0	1	0	0	0	2	3
Sales and Distribution	0	0	0	3	0	1	0	4	5
Consulting	0	0	0	1	1	0	0	2	3
Other	0	0	0	3	0	1	0	4	5
TOTAL	3	3	4	78	13	10	5	116*	

* - Companies could list more than one area of activity

Exhibit 5.4: Most (66%) of the companies surveyed noted that they are involved in manufacturing activities, 29% are involved in engineering and design, 16% are involved in research and development and 12% are involved in operations and maintenance services. In general, companies that supply to the nuclear industry are involved in more than one area of activity.

Exhibit 5.5: Breakdown of Products of Products and Services Supplied to the Nuclear Industry

		TOTAL
PRODUCTS ONLY		36 7%
• Machine or Fabricated Components	45%	
• Inspection and Monitoring Products	32%	
• Process Systems	17%	
• Resource Products	16%	
• Software	5%	
• Storage Systems	5%	
• Other	8%	
SERVICES ONLY		10 13%
• Engineering & Design	35%	
• Machining and Repair	28%	
• Inspection & Licensing	23%	
• Consulting	18%	
• Emergency Services	10%	
• Training	8%	
• Transportation	5%	
• Resources Control & Monitoring	5%	
• Research and Development	5%	
• Other	25%	
BOTH PRODUCTS/SERVICES		30 39%
No Response		1 1%
TOTAL		77

Exhibit 5.5: Of the survey respondents, 47% supply only products to the nuclear industry, 13% supply only services and 39% supply both products and services. In general, individual companies often supply more than one type of product or service.

Exhibit 5.6: Volume of Business by Major Customers, 1992

MAJOR CUSTOMERS	PERCENTAGE
AECL	11%
Ontario Hydro	20%
Private Companies	22%
Hydro-Quebec	1%
NB Power	2%
Power Company: US	1%
Power Company: Other Int'l	2%
Universities	1%
Research Institutes	0%
Military Establishments	0%
AECB	0%
Governmental Departments and Organizations	2%
Numerous Small Customers	38%

Exhibit 5.6: The major buyers of nuclear-related products and/or services in Canada are AECL, the utilities (predominantly Ontario Hydro) and private companies.

Exhibit 5.7: Under-Utilization of Equipment by Region

Location	YES	%	NO	%	*No Response*	TOTAL
B.C.	0	0%	1	100%	0	1
Alberta	1	25%	3	75%	0	4
Sask.	2	50%	1	25%	1	4
Ontario	31	62%	10	20%	9	50
Quebec	3	30%	3	27%	5	11
N.B.	2	50%	0	0%	2	4
U.S.	3	100%	0	0%	0	3
TOTAL	42		18		17	77
PERCENT	55%		23%		22%	100%

Exhibit 5.8: Under-Utilization of Personnel by Region

Location	YES	%	NO	%	No Response	TOTAL
B.C.	0	0%	1	100%	0	1
Alberta	1	25%	3	75%	0	4
Sask.	2	50%	1	25%	1	4
Ontario	28	56%	16	32%	6	50
Quebec	3	30%	4	36%	4	11
N.B.	3	75%	1	25%	0	4
U.S.	3	100%	0	0%	0	3
TOTAL	40		26		11	77
PERCENT	52%		34%		14%	100%

Exhibits 5.7 and 5.8: Respondents indicated that there is a significant excess capacity with respect to supplying the nuclear industry. Specifically, a majority of respondents from Ontario noted that they were under-utilizing their specialized equipment and staff.

Exhibit 5.9: Under-Utilization of Equipment

COMPANIES SUPPLYING...	YES	%	NO	%	No Response	TOTAL
Products only	24	67%	8	22%	4	36
Services only	3	30%	1	10%	7	10
Both	14	47%	9	30%	7	31
TOTAL	41		18		18	77
PERCENT	53.2%		23.3%		23.3%	100%

Exhibit 5.10: Under-Utilization of Personnel

COMPANIES SUPPLYING...	YES	%	NO	%	No Response	TOTAL
Products only	18	50%	13	36%	5	36
Services only	5	50%	1	10%	4	10
Both	16	53%	12	40%	3	31
TOTAL	39		26		12	77
PERCENT	51%		34%		15%	100%

Exhibits 5.9 and 5.10: While the under-utilization of equipment is more significant in the manufacturing as opposed to the services sector, it is fairly even with respect to the under-utilization of personnel.

Exhibit 5.11: Partnerships and Collaborations

COLLABORATIONS	*Number*	*Percent*
Yes	32	42%
No	44	57%
No Response	1	1%
TOTAL	77	100%
TYPES OF COLLABORATIONS*	Number	Percent
Other Companies (Domestic)	18	32%
Other Companies (Int'l)	18	32%
Universities (Domestic)	10	18%
Universities (Int'l))	3	5%
Industry Group (Domestic)	5	8%
Industry Group (Int'l))	0	0%
Utilities, Sub-Vendors & Research Institutes	3	5%
TOTAL COLLABORATIONS	57	100%

* The 32 respondents to this question were involved in more than one type of collaboration.

Exhibit 5.11: Forty-two percent of the respondents noted that they currently had collaborative ventures/partnerships with universities and/or other companies to enable them to supply to the nuclear industry. A majority of these ventures were with other companies. Specifically, 32% were with other Canadian companies, 32% with other companies world-wide and 18% with Canadian universities.

Exhibit 5.12: Location of Production Facilities

LOCATION	ONLY IN CANADA	IN CANADA & ABROAD	NO RESPONSE	TOTAL
B.C.	1	0	0	1
Alberta	2	2	0	4
Sask.	2	1	1	4
Ontario	29	20	1	50
Quebec	6	2	3	11
N.B.	4	0	0	4
U.S.	0	1	2	3
TOTAL	44	26	7	77
PERCENT	57%	34%	9%	100%

Exhibit 5.12: Fifty-seven percent of the respondents noted that they had domestic production facilities and 34% noted that they had offices both in Canada and abroad.

Exhibit 5.13: Private Sector Employment by Region[84]

Location	All Employees	Full-Time Employees	Part-Time Employees	% of Time by Part-time on Nuclear
B.C.	3	3	0	0%
Alberta	17	6	6	17%
Sask.	1,336	1,306	30	19%
Ontario	2,736	2,381	339	37%
Quebec	1,052	930	122	43%
N.B.	57	41	0	0%
U.S.	5	5	0	0%
TOTAL	5,206[85]	4,672	497	
PERCENT	99%[86]	89%	10%	

Exhibit 5.13: The 66 private-sector companies who responded to this question noted that a total of 5,206 employees worked in nuclear-related activities. A majority of these jobs are in Ontario. Of these, about 90% of

[84]Includes only employees with private sector suppliers.

[85] Of these, 1866 are employees in 5 uranium companies.

[86] Some respondents did not provide the breakdown of employees by full-time and part-time. Hence the numbers 4,672 and 497 do not add to 5,206.

employees are occupied full-time with nuclear-related activities. In addition, about 500 employees work approximately 40% of their time in nuclear business related areas. The 5,206 employees are paid total wages of $112 million annually. Thirty of these 43 companies reported spending $87 million on training costs each year. Note that the Saskatchewan numbers include the uranium mining sector.

Exhibit 5.14: Change in Number of Employees in Nuclear Activities in Last Five Years

	INCREASED	DECREASED	CONSTANT	NO RESPONSE	TOTAL
Products	4	13	16	3	36
Services	3	3	4	0	10
Both	11	6	11	3	31
TOTAL	18	22	31	6	77
PERCENT	23%	29%	40%	8%	100%

Exhibit 5.14: For the most part, respondents replied that the number of employees engaged in nuclear-related activities had remained the same over the last five years. Twenty-nine percent observed that the number of employees had decreased and 23% noted that it had increased significantly.

In general, in the last five years, it appears that employment has increased in engineering and design services and R&D, and has decreased or remained the same in manufacturing, mining and refining of uranium.

Exhibit 5.15: Factors Influencing Requirements for Skilled Employees in the Future

	INCREASE	DECREASE	CONSTANT	NO RESPONSE	TOTAL	%
Economic Outlook of the Industry	8	7	3	2	20	26%
Financial Factors	0	1	0	0	1	1%
Human Resource Factors	1	0	0	0	1	1%
Other Factors	3	0	1	0	3	4%
No Reasons Provided	5	5	32	10	52	68%
TOTAL	17	13	35	12	77	100%
PERCENT	22%	17%	45%	16%	100%	

Exhibit 5.15: Most respondents expect no changes in their future skill needs. Twenty-two percent indicate that their requirements for skilled employees would increase while 13% indicated that it would decrease.

Exhibit 5.16: Annual Sales for Last Five Years ($ millions)

COMPANIES SUPPLYING........	PRODUCTS	SERVICES	BOTH	TOTAL
1989	$135.2	$8.0	$450.5	$593.7
1990	$136.4	$10.7	$424.7	$571.8
1991	$138.4	$7.8	$433.2	$579.4
1992	$289.8	$42.0	$444.0	$775.8
1993**	$164.2	$40.0	$740.7	$944.9
TOTAL	$864.0	$108.6	$2,493.1	$3,465.6
5-Year Average	$172.8	$21.7	$498.6	$693.1

** Reflects partial year statistics

Exhibit 5.16: Forty-four companies reported that over the five years between 1989 and 1993, their total nuclear related sales amounted to approximately $3.5 billion cumulatively. We estimate the total sales of private sector suppliers as a whole at $9.4 billion for the five years between 1989 and 1993.

These figures represent an increase in nominal terms of 23% annually over the estimated sales volume of $350 million in 1977[87]. In real terms, this represents an increase of 17% annually (Using Statistics Canada GDP deflators of 60.0 for 1978 and 123.1 for 1992).

Survey respondents indicated that over the last five years, 60% of sales have been to the domestic market and 40% have been export sales. Nearly all respondents expect that over the next five years this proportion will reverse and export sales will comprise 60% of total sales.

Respondents reported that in the last five years the bulk of their exports were to Korea, followed by the United States and Romania. Other export markets for these suppliers included Taiwan, Malaysia, Turkey and Argentina.

Exhibit 5.17: Plans to Increase Sales in Next 5 Years

	DOMESTIC SALES			EXPORTS SALES			
	PLANS	NO PLANS	NO RESP.	PLANS	NO PLANS	NO RESP.	TOTAL
Products	11	18	7	20	10	6	36
Services	5	3	2	7	2	1	10
Both	15	11	5	18	7	6	31
TOTAL	31	32	14	45	19	13	77
PERCENT	40%	42%	18%	58%	25%	17%	100%

Exhibit 5.17: Companies are fairly split about plans to increase domestic sales in the future. Specifically, 40% of the respondents expect domestic sales to increase while 40% expect no increases. With respect to export sales, however, 58% of respondents expect export sales to increase while 25% expect no increases.

87 Nuclear Industry Report, Leonard and Partners Ltd. 1978

Exhibit 5.18: Companies were asked to identify the benefits that have accrued to them as a result of supplying to the nuclear industry. Thirty-three percent of the companies replied that participation in the nuclear industry had helped them improve the quality of their products and services, 12% noted that it had helped them improve safety standards, 23% noted increased access to foreign nuclear markets and 20% noted that participation in the nuclear industry had allowed them increased access to new markets in non-nuclear areas.

Exhibit 5.18: Benefits Accrued to Companies

BENEFITS	PRODUCTS	SERVICES	BOTH	TOTAL	PERCENT
Increased quality of products & services	17	7	13	37	33%
Increased access to foreign nucl. markets	11	3	12	26	23%
Increased access to new markets in non-nuclear areas in Canada	13	5	5	23	20%
Improved safety standards	3	4	6	13	12%
Increased access to new markets in non-nuclear areas abroad	8	1	2	11	9%
No Response	0		3	3	3%
TOTAL	52	20	41	113*	

*- Respondents could identify more than one benefit.

Exhibit 5.19: Threats and Opportunities Identified by Clients and Users

	NUMBER	PERCENT
THREAT		
Negative stereotype of the nuclear industry	16	30%
Bad economy / lack of industry growth	25	47%
Financial aspects of nuclear energy	8	15%
Canadian government policy	5	9%
Human resource deficiencies	8	15%
Foreign competition	5	9%
Lacking commitment from customers	4	8%
OPPORTUNITY		
Positive outlook for demand	16	30%
Maintenance requirements of industry	8	15%
Popularity of CANDU reactors	6	11%
Military and industrial decommissioning	6	11%
Private sector vs. Public sector	1	2%
Other	3	6%

Exhibit 5.19: A majority of respondents identified the economic outlook and negative image of the industry as two key threats in the future. Difficulty in obtaining financing and a lack of skilled human resources were also identified as potential future threats.

In terms of opportunities, 30% of the companies saw the positive outlook for demand as an opportunity. This opportunity is complemented by maintenance requirements in the industry, the popularity of CANDU reactors and the decommissioning of military and industrial establishments.

Section Six: Conclusion

We conclude that the economic effects of the Canadian nuclear industry have been substantial. Over the past 31 years, the GDP contributions of the nuclear power generation industry has been $23 billion (as-spent dollars). In particular, the GDP contributions for 1992 were $3.46 billion.

The nuclear industry also supports approximately 40,000 direct and indirect Canadian jobs associated with both nuclear research and CANDU technology.

Spin-off benefits from the nuclear industry have augmented Canadian technological and commercial capabilities in other sectors such as agriculture, medicine and the environment. For example, commercial operations such as Nordion and Theratronics are directly linked to the government's decision to appropriate funds for the development of nuclear applications.

Increased quality standards for Canadian manufacturing companies are a result of the stringent standard demanded for goods produced for nuclear application. Such standards have allowed companies supplying the industry to gain a competitive advantage in technical design and engineering.

Until recently, AECL had focused primarily on enhancing the capacity of the domestic market. At the present, nuclear power is supplying close to 20% of Canada's electricity needs. However, there are no concrete plans for developing new nuclear generating plants in Canada and, with the temporary decline for new domestic nuclear capacity, the industry is pursuing export opportunities. This strategy has been successful as seen by the recent signing of the Wolsong 3 and 4 contracts with South Korea.

Based on our study, we conclude that the Canadian nuclear industry has the capability to sustain current levels of economic activity through export projects assuming the current base of 22 nuclear reactors in Canada is maintained. Our findings indicate that there is an excess of electricity on the market. However, assuming that this situation will transform into a long term trend is ill-advised. Long term predictions show electricity needs will increase as the Canadian economy either stabilizes or grows. Since nuclear is an important component in Canada's electricity mix, substitution by an alternative fuel type would be costly in both economic and environmental terms.

In 1992, the nuclear industry had a positive trade balance of $250 million, one of the two industries within the high technology sector to do so. The industry must continue to find new opportunities abroad to maintain the technological advances and ensure qualified human resources remain trained in the nuclear field. This will help maintain Canada's nuclear capability for future use when domestic demand for nuclear energy strengthens. Future nuclear exports will help safeguard Canada's investment in the nuclear industry and will maintain nuclear as a viable energy option.

recognize that this federal investment is incremental and has been leveraged by other public and private sector investments which together have resulted in the effects described in this study.

With respect to effects, both economic and non-economic effects in aggregate form, i.e., for the nation as a whole, were sought. Impacts on specific regions/communities are presented only where such information/analysis was readily available.

7.3 Study Methodology

The information required to conduct this economic impact study was collected using the following five methods.

- Mail survey of 154 Canadian companies which supply products and/or services to the nuclear industry (a response rate of 50% was achieved),
- Interviews with 35 industry stakeholders,
- Review of 150 relevant reports and documents,
- Case studies of 5 successful companies, and
- Input-output analysis using Statistics Canada's Open Output Determination Model.

The methodology was designed to obtain the most up-to-date and reliable data directly from the primary sources. Where it was necessary to use secondary data, we cross-checked/verified them with the primary sources to the greatest extent possible. All sources, whether primary or secondary, have been referenced accordingly in the report. Limitations with the data have also been identified where relevant.

The specific activities that were undertaken are detailed below:
1. Survey of Suppliers: A main feature of our work was a canvassing of the views of as many industry players as possible. We conducted a mail survey of 154 companies which supply products and/or services to the nuclear industry in Canada. The survey was designed to obtain the following types of information.

Section Seven: Methodology Report

7.1 Study Objectives

The objective of Ernst & Young with this study was to document the economic contribution of the nuclear industry in Canada and abroad to the Canadian economy. Therefore, the major costs and benefits associated with government investment, largely federal, in the nuclear industry were documented.

In more immediate terms, another goal was to update the previous study of the effects of the Canadian nuclear industry completed by Leonard and Partners Limited in 1978.

7.2 Study Scope

The term "nuclear industry" was defined to include all activities directly related to the design, construction, equipment supply and operation of nuclear power facilities. This covered activities such as research and development, engineering, manufacturing, uranium mining and refining and maintenance services.

For the purposes of this study, the scope did not include activities in spin-off industries such as health sciences or agriculture that rely on nuclear technology. The only exceptions to this were Nordion International Inc. and Theratronics International Ltd., both of which were divisions of Atomic Energy of Canada Limited (AECL) until 1989. Beyond a qualitative discussion, our definition of economic effects also did not attempt to financially quantify the environmental and medical benefits from the use of nuclear technology.

We defined "government investment" as federal government expenditures on the nuclear industry including appropriations and write-offs. We

- Types of products and/or services provided by Canadian suppliers;
- Information on major suppliers and customers and percent of business done with each;
- Performance of the industry as measured by employment, domestic and foreign sales, capital expenditure, and other incremental benefits of supplying to the nuclear industry;
- Factors affecting competitiveness of the nuclear industry in Canada; and
- Challenges and opportunities facing the industry.

2. Interviews with industry experts and stakeholders: Interviews were conducted with 35 industry experts/stakeholders from, among others, AECL, the Canadian Nuclear Association (CNA), Ontario Hydro, Natural Resources Canada[88] (NRCan), Industry and Science Canada[89] (ISC) and Environment Canada. The interviews were designed to complement information gathered from the review of relevant reports. In particular, the interviews were designed to discuss the following issues:

- the "whys and hows" underlying the data presented in various reports;
- the recent performance of the nuclear industry;
- the relative advantages of nuclear energy versus other forms of energy;
- the main issues and challenges facing the industry; and
- future opportunities.

3. Review of Relevant Reports and Documents: We reviewed 115 reports and documents available from various sources including the AECL library, CNA library, Ontario Hydro and other government departments such as EMR. The focus of this search was on relevant material covering the period from 1978 to 1993 period.

4. Case Studies: In previous economic impact studies, we have often found it useful to document interesting case studies on the impact of a given sector. Such case studies can be useful in applying a "human face" to a

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study - bringing reference to particular companies, employees, advances in R&D, spin-offs and other developments. Case study candidates were chosen to reflect regional representation and diversity in the types of products and services provided. In consultation with AECL, we selected the following Canadian companies for case studies:

- Babcock & Wilcox (Ontario)
- Sulzer Bingham (British Columbia)
- Velan (Quebec)
- CANATOM (Ontario and Quebec)
- Theratronics (Ontario)

5. Input-Output Analysis: As a final step to the methodology, we enhanced the economic impact assessment through the use of Statistics Canada's Open Output Determination Model. The model provided a detailed breakdown of all the inputs and outputs of commodities associated with the production of a specified amount of nuclear energy for a one year period. The model also determined the source of the inputs supplied such as domestic production, imports and government production.