The Nuclear Option and Climate Change

... A necessary part of Canada's Kyoto Implementation Strategy

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Presentation to the

19th Annual Conference of the Canadian Nuclear Society
Holiday Inn on King, Toronto
October 19, 1998

Abstract

Nuclear power is clean sustainable electricity, and should be a part of Canada's implementation strategy to meet its Kyoto Protocol commitments. Canada has world leading nuclear technology, systems and fuel supply capabilities that can benefit Canada, both by enhancing domestic actions and by leveraging the Flexibility Mechanisms incorporated into the Kyoto Protocol.

This paper illustrates these objectives by first reviewing the current state of the nuclear industry in Canada and the global commitment to nuclear power generation. The past, current and future potential of nuclear power generation to reduce greenhouse gas emissions is highlighted. Specific examples are presented to show that Canadian exports are significantly reducing global greenhouse gas emissions.

This paper demonstrates that nuclear generation of electricity is one of the leading sustainable development technologies and should be used, along with all other forms of low and zero-emitting greenhouse gas technologies, by Canada and other nations to reduce greenhouse gas emissions.

Introduction

Nuclear power is clean sustainable electricity. Therefore, nuclear generation of electricity can and should be part of both Canada's and the world's solution to reducing climate change gas emission levels.

This paper will discuss this objective under three major headings:

- The status of the Canadian nuclear industry,
- The global status and competitiveness of nuclear power generation, and
- The contribution of nuclear power to reduce global greenhouse gas emissions.

The Canadian Nuclear Advantage

Over the past fifty years Canada has developed world leading nuclear technology which has considerable commercial success and has made a major economic, social and environmental contribution to Canada. Canada's nuclear industry can be separated into three major sectors as shown below.

- **Uranium mining and processing**
  - world leader
- **Medical, food irradiation & industrial isotopes**
  - world leader
  - one-third of all hospital patients use nuclear medicine
- **Power Generation and CANDU**
  - 17% of Canada's electricity generation
  - Canadian "flagship" becoming the reactor of choice in export markets.

In summary, proven benefits from these sectors include:

- 30,000 direct jobs in the high technology sector spread over 150 companies across Canada.
- A $6 Billion contribution to Canada's GDP.
- Canada's nuclear energy production has avoided the production of:
  - over one billion tonnes of carbon dioxide
  - 80 million tonnes of ash (with heavy metals)
  - 32 million tonnes of sulfur dioxide

- Canada is the world's leading supplier of uranium with mines in Saskatchewan and all final processing and fuel fabrication done in Ontario.
- Canada is the world's leading supplier of radioactive isotopes for medical, industrial and food processing uses.
- Nuclear energy supplies approximately 17% of Canada's electricity and over half of Ontario's electricity.
- Canadian CANDU reactors are currently being constructed in China, Korea and Romania - one of Canada's most successful high technology export products.
- The nuclear industry generates $700 million each year in income and sales taxes.
- Approximately $1 billion per year in foreign exchange benefits are achieved by not importing fuel for electricity generation.
- Canada is a signatory to the Nuclear Non-proliferation Treaty and only does business with countries that have not only signed this Treaty, but also have agreed to an even more stringent bilateral Nuclear Co-operation Agreement.

In the recent Canadian Nuclear Association submission to the Ontario Legislative Standing Committee on Resources Development, considering Bill 35, *The Energy Competition Act, 1998*, the Association strongly supported an *"... open competitive electricity market in Ontario."* Competition *"... will allow the nuclear industry, including the nuclear assets of the current Ontario Hydro, to demonstrate the economic, social and environmental benefits of nuclear technology ..."* and *"... nuclear power generation is the only viable short, medium and long term electrical generation option for Ontario that will meet its future electricity requirements competitively, while simultaneously improving the air quality of Ontario and meeting any anticipated requirements of the 1997 Kyoto Protocol on Climate Change."*

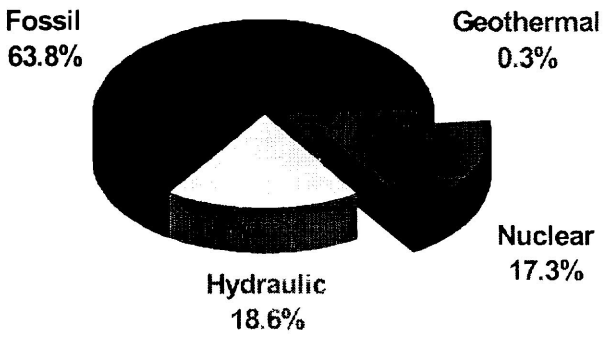
The Canadian nuclear industry has both the technology and the expertise to supply the nuclear option as a part of Canada's Kyoto implementation strategy.

The Global Commitment to Nuclear Power

Nuclear power currently supplies approximately 17% of the world's electricity. This is almost equivalent to hydro electric power generation, but the two are overshadowed by the high dependence on fossil fuels.

The following chart shows the current global electricity generation mix by major fuel type.

WORLD ELECTRICITY GENERATION BY FUEL TYPE



Hydro electric power generation facilities have been developed for over one-hundred years. Most of the suitable sites near areas of high demand for power are already developed, especially in industrialized economies.

Nuclear power plants, however, require little land and can be built near the electricity demand. Today, there are approximately 30 nuclear reactors under construction around the world, and another 15 in the final planning stages. Fifteen of the 31 countries currently with nuclear power generation capabilities have additional nuclear power plants under construction. These figures do not include the recent announcement by Japan to build an additional 10 to 20 new nuclear units to help Japan meet its Kyoto Protocol commitments.

Globally, during 1997 there was a net increase of almost 7000 megawatts of nuclear power generation brought on line. New large nuclear units coming on line are more than offsetting smaller, older units being decommissioned in North America and Europe.

The economic structure of nuclear power is very similar to that of hydroelectricity and many forms of alternative energy. The greatest part of the cost of electricity from nuclear power comes from building the power station, with only a small fraction coming from fuel supply. Like hydroelectricity, this means that the cost of electricity from a nuclear power station is highly predictable over the life of the power station. It is not dependent upon the variability of commodity prices, as are fossil fuel-fired installations.

In making economic comparisons, it can be observed that nuclear energy, like hydroelectricity has fully internalized its own external costs. A decommissioning plan and a waste fuel management plan are a condition of having an operating license. All these residual costs from a nuclear power plant are included in the basic cost consumers pay for nuclear generated electricity. Having no emissions or waste products, alternative sources and hydroelectricity have also captured their external costs with the potential exception of mercury contamination resulting from the flooding caused by large hydro

dams. However, fossil fuel generation captures very little of its external costs, as carbon dioxide and nitrous oxides are emitted to the atmosphere uncontrolled, and in older plants there are little or no controls on sulphur dioxide.

Even given the free ride on external costs that fossil fuels currently enjoy, in many places around the world nuclear energy has large advantages in electricity generating costs over fossil fuels. The economics of comparative forms of electricity generation are site-specific. In general terms, nuclear power has a strong advantage over any of the fossil fuels in locations where no local supply of fossil fuels exists. Nuclear energy can have an advantage over hydroelectricity in situations where the hydraulic site is remote from demand, requiring extensive transmission systems.

Natural Resources Canada recently completed a study of electricity generation costs.[1] These costs were assessed on a lifetime, complete fuel cycle basis assuming a 5% real discount rate. This cost comparison method - Levelized Unit Energy Cost (LUEC) is a well accepted method of comparing the lifetime cost of energy alternatives.

As is shown in the chart below, for power stations situated in Central Canada, nuclear power is competitive with the other proven energy generation technologies.

LUEC at the 5% Real Discount Rate (CDN mills/Kwh)

Unit Type	O&M	Fuel	Investment	LUEC
CANDU 9 (2x881 MWe)	8.1	3.1	23	34.2
CANDU 6 (2x665 MWe)	11.4	3.3	25.1	39.8
CC Gas Turbine (2x750 MWe)	2.7	30.5	11.2	44.4
Coal (4x750 MWe)	5.4	23.9	13.8	43.1

Nuclear plants were found to be sensitive to capital costs, discount rates, capacity factors and plant life, while fossil fuels were found to be sensitive to the cost of fuel. Capital cost increases have a greater impact on LUEC than plant life extension for nuclear plants, although life extension of existing plants was generally more economic than building new ones. NRCan noted that its study of plant costs did not include infrastructure costs, employment impacts or environmental externalities.

Those countries investing in nuclear power are those that will have the advantage in effectively controlling greenhouse gas emissions in the future, while maintaining economic growth. Interestingly, the prime reason for selecting nuclear power was based on power cost advantages, not environmental benefits. As environmental concerns are

[1] Comparative costs of electricity generation: a Canadian Perspective. Moore and Guindon, NRCan, 1998.

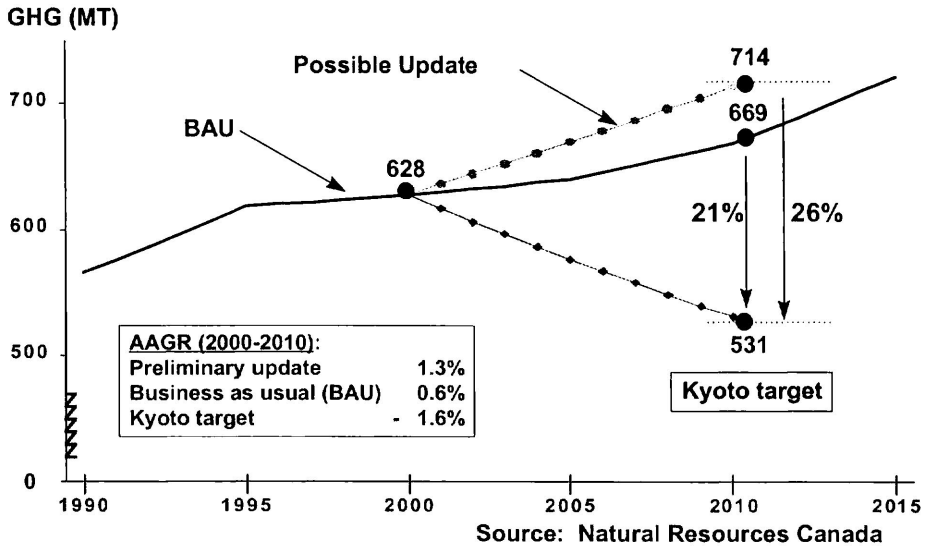
factored in the decision process, we anticipate an even greater acceleration of the building of nuclear units around the world.

The Contribution of Nuclear Power to Reduce Greenhouse Gas Emissions

The Third Conference of the Parties (COP3), including Canada, met in Kyoto in December 1997 and reached agreement on a **FRAMEWORK CONVENTION ON CLIMATE CHANGE**. Once ratified, this Convention will impose defined targets for the permitted emission levels of climate change gases, including carbon dioxide. The Convention sets these targets based on the emission levels in 1990. The overall, global, requirement by 2008 to 2012 is a reduction to 5 percent below the 1990 levels. Canada's required reduction is 6 percent.

This presents Canada with a major challenge. The Canadian 1990 green house gas emissions were 564 million tonnes. By 1995 this had risen to 618 million tonnes. The current projection for Canada for 2010 is emission levels of 714 million tonnes. To meet our commitment, Canada must reduce emissions to 531 tonnes - a **26% reduction** from the "business-as-usual" projections.

KYOTO PROTOCOL - A BIGGER CHALLENGE?

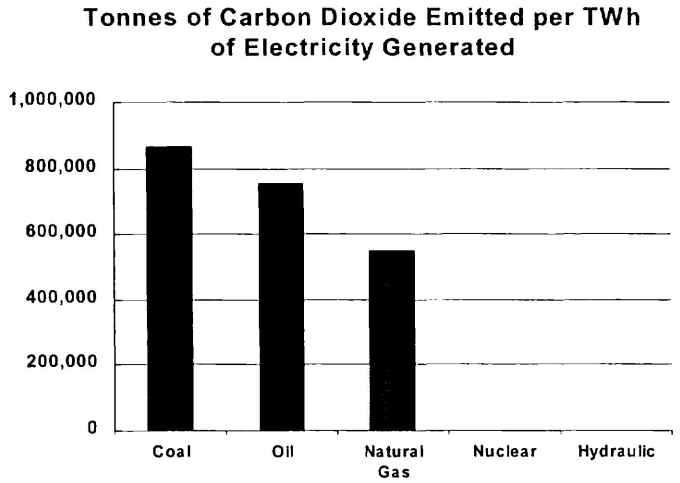


Source: Natural Resources Canada

Nuclear power generation should be part of Canada's solution to meeting this challenge. This applies to both its domestic actions and its utilization of the three "Flexibility Mechanisms" included in the Kyoto Protocol: International Emissions Trading, Joint Implementation projects and Clean Development Mechanism projects.

Electricity produced by commercial nuclear power reactors is clean power. Nuclear power fully meets the criteria of being a Sustainable Development technology as defined by the accepted Bruntland definition and also as defined by the Canadian government policy on Sustainable Development. Some facts about nuclear generated electricity are:

- Nuclear power generation is zero-emitting with respect to greenhouse gas emissions.



- No solid wastes are released to the environment from a nuclear power plant.

  All solid wastes produced in the nuclear plant, including the spent nuclear fuel, are totally contained and safely managed in storage systems that have passed rigorous environmental assessments, which have included comprehensive public reviews and regulatory scrutiny.

- The production of nuclear fuel, from the mining of the uranium and its associated tailing disposal, through fuel processing and final fuel bundle manufacturing and transportation, is performed under stringent licensing requirements. All of these activities have also passed numerous environmental assessments with public participation.

- All minor emissions from nuclear facilities (e.g. Carbon 14, Tritium) are essentially at background radiation levels, and certainly well below any internationally accepted level at which it has been proven there are no harmful effects on humans and the environment.

- Nuclear electricity generation is one of the safest forms of electricity generation. The strict regulatory requirements on nuclear plants demands a safety culture. There have been no reported deaths of any nuclear worker from radiation effects, from any nuclear reactor in the Western world. It is important to note that the Chernobyl

reactor type could never have been approved for construction and operation in any country outside of the former Soviet Union.

- All activities of the nuclear industry are performed under the strict control and licensing of Canada's independent regulatory agency - the Atomic Energy Control Board. New federal legislation has been passed that will continue to assure that Canada's regulatory regime is the most modern and effective system in the world.

- Nuclear power plants are reliable. Notwithstanding the recent difficulties at Ontario Hydro Nuclear, nuclear power plants around the world, including many CANDU reactors, have high availability factors and are invariably used as base load power generation sources due to this high reliability.

- Nuclear electricity generation is economically competitive. This has been confirmed in Ontario, and has been demonstrated time and time again in the many countries around the world that continue to build additional reactors based on economic analyses of all the commercial options.

- The known reserves of uranium deposits, combined with proven technology for recycling and reprocessing of spent fuel, gives essentially an infinite source of fuel for nuclear electricity generation. Uranium is also a material with no other significant commercial use and hence this is one of the best raw materials for electricity generation.

More specifically, nuclear power has demonstrated its ability to reduce greenhouse gas emissions. On a global basis the effect of nuclear power is staggering:

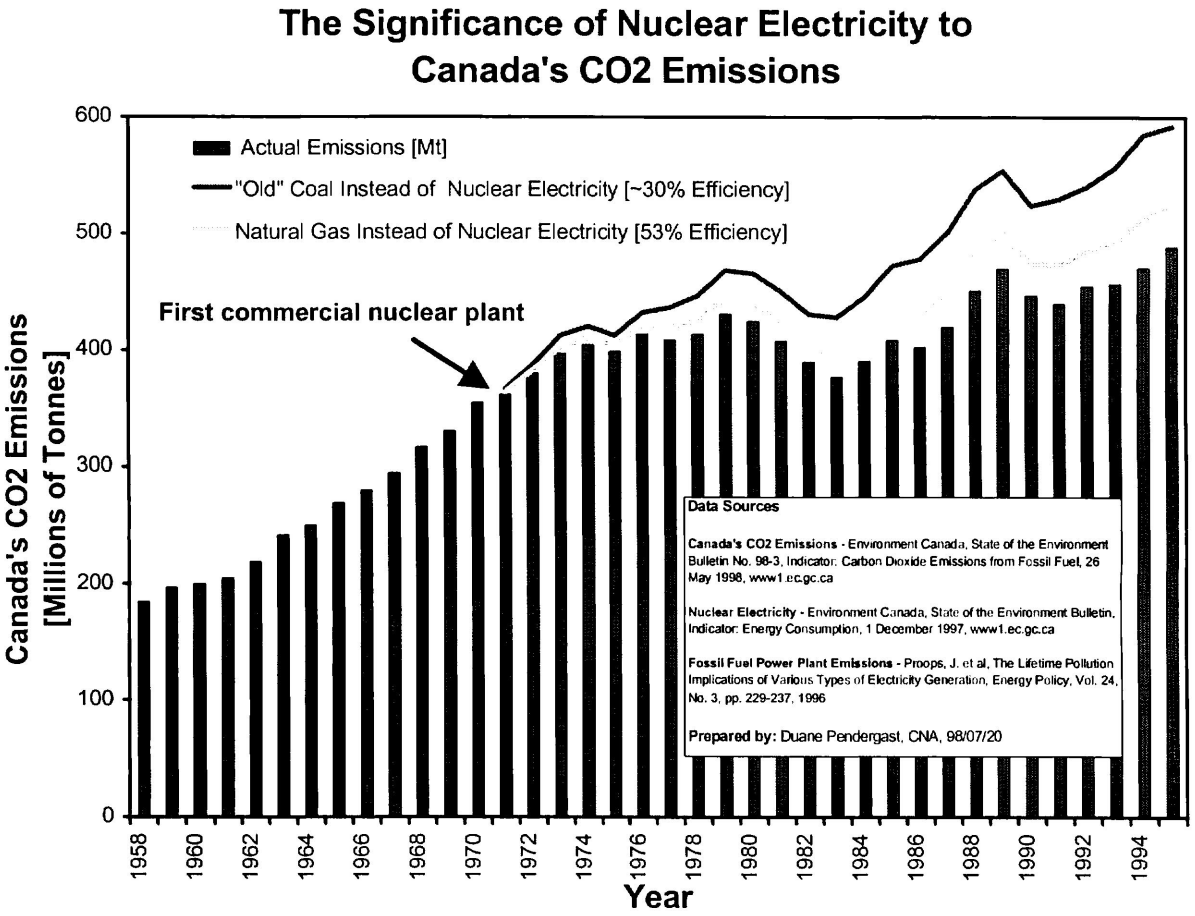
- **Nuclear energy has reduced carbon dioxide emissions by:**

  1.8 billion tonnes in 1995

  22 billion tonnes since 1973

- **Electric utilities would have emitted 32% more carbon dioxide in 1995 without their nuclear generating capacity.**

In Canada this reduction is clearly shown in the figure below.

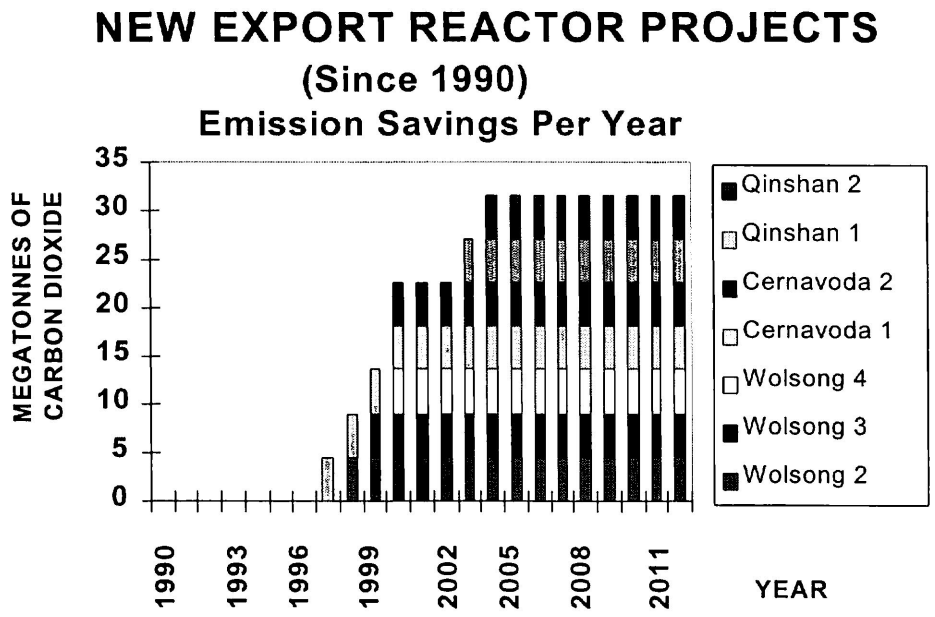


Since the first commercial power reactors in Canada, our nuclear stations have avoided well over one billion tonnes of carbon dioxide emissions into the atmosphere.

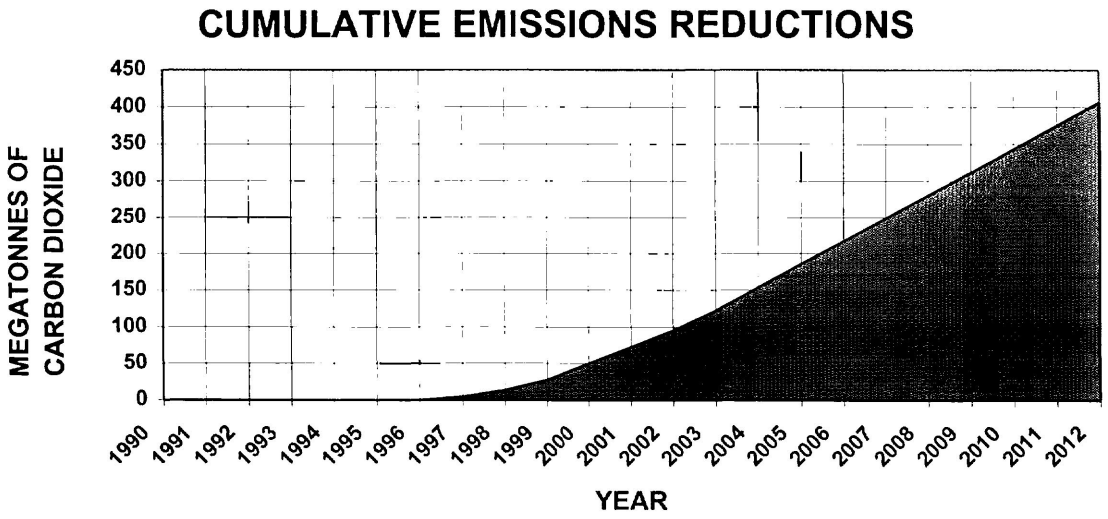
Nuclear technology based projects are eminently suited for inclusion in many countries strategies for Joint Implementation and Clean Development Mechanism projects, thus assuring that these countries have the ability to meet their greenhouse gas commitments.

Using Canada as an example, activities since 1990 illustrate how Joint Implementation and the Clean Development Mechanism could be used in the future for the collective benefit of many countries, not just Canada. Since 1990 Canadian CANDU® technology has been used for new nuclear reactors in Korea, Romania and China. In each case, there is a significant technology transfer from Canada to the other country. In the case of Korea, this technology transfer has been to such a great extent that Korea is now a significant sub-supplier to Canada on other third party projects, such as the Qinshan project in China. Also, in several of these projects financing from Canada and its partners allowed the project to proceed. In each of the projects, the alternative fuel source was fossil fuels, primarily coal, but for economic reasons the nuclear option was chosen.

The following chart illustrates the reduction in greenhouse gas emissions that will occur as a result of these projects, noting again that they were all initiated since the United Nations Framework Convention on Climate Change was adopted.



On a cumulative basis, the impact of these joint projects is substantial, over 400 million tonnes of avoided carbon dioxide up to the year 2012, as shown by the following chart.



Canada has another commodity that should be considered for both Joint Implementation and Clean Development Mechanism projects. Currently Canada supplies over one-third of the world's uranium for peaceful nuclear power generation. Production levels are currently being increased to meet the growing need for uranium for the global expansion of nuclear power. In this way, Canada is also a major contributor to global greenhouse

gas reductions for many more nuclear power reactors than just those based on the Canadian CANDU technology.

Between 1998 and 2007 global nuclear power generation is expected to increase from 357,000 megawatts to 384,000 megawatts, based on the current plants under construction, planned and scheduled for de-commissioning. **This net increase of 27,000 megawatts will give an overall annual reduction of carbon dioxide of 110 to 175 million tonnes depending on the alternative fuel source that would have been chosen, rather than nuclear.**

It should be also noted that the above projects are for the primary purpose of generating electricity to feed into the national electricity grid of each country. There are other potential uses of nuclear energy that could be of great benefit to both Annex I and the other countries. Only 30% of the world's primary energy is converted to electricity. The other 70% is used for industrial processes, space heating and all forms of transportation. Nuclear energy can be used to reduce greenhouse gas emissions from these other uses which are currently dominant fossil fuel users. For example, nuclear energy can be used to produce hydrogen for fuel cells for automobiles, trucks and buses. Nuclear energy can also provide the energy for desalination processes, as well as more conventional industrial process heat.

Conclusion

Canada has become a world leader in nuclear technology and fuel supply. This capability, coupled with nuclear power's proven economic, social and environmental benefits can make a major contribution to Canada and the world.

Nuclear power should be an important part of Canada's energy policy and its plan to meet its Kyoto Protocol commitments.

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