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Exposé oral

Submission from the Canadian Nuclear Society (CNS)

Mémoire de la Société nucléaire canadienne

In the Matter of

À l'égard de

Bruce Power Inc. – Bruce A and B Nuclear Generating Station

Bruce Power Inc. - Centrale nucléaire de Bruce A et Bruce B

Request for a ten-year renewal of its Nuclear Power Reactor Operating Licence for the Bruce A and B Nuclear Generating Station

Demande de renouvellement, pour une période de dix ans, de son permis d'exploitation d'un réacteur nucléaire de puissance à la centrale nucléaire de Bruce A et Bruce B

Commission Public Hearing – Part 2

Audience publique de la Commission – Partie 2

May 28-31, 2018

28-31 mai 2018

Canada

Intervention by the Canadian Nuclear Society (CNS)
Before the Canadian Nuclear Safety Commission (CNSC)

Application by Bruce Power
To renew for a ten year term
(Ref 2018-H-02)

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Introduction

The Canadian Nuclear Society (CNS) views with great interest the renewal of the operating licence for the Bruce nuclear power station under review today during Day 2 of the hearings by the Canadian Nuclear Safety Commission (CNSC). In this short paper, the CNS will present some perspective on the importance of the Bruce NGS and the role nuclear power plays in Canada and in the province of Ontario.

We will address three areas of interest with respect to the continued operation of the Bruce station:

- The strong continued safety record of all CANDU reactors;
- Consistent, strong safety performance at Bruce Power;
- Major Component Replacement Program at Bruce Power;

The licensing of a nuclear facility is not an abstract activity. To operate, all regulated nuclear facilities in Canada must meet the safety performance requirements of the CNSC. However, all regulated nuclear facilities in Canada exist for important commercial, research, or energy supply reasons. This means that licensing decisions have direct research, technical and commercial consequences. This paper provides the views of the CNS on the importance of these licensing decisions.

The CNS is Canada's learned society for the nuclear industry. We are a not-for-profit organization representing more than 1,000 scientists, engineers and other nuclear professionals engaged in various aspects within Canada's nuclear industry. We do not represent any company or other organization within the industry. The CNS believes that the views of Canada's nuclear professionals, as embodied by its learned society, may provide useful assistance to the CNSC in its deliberations.

I Nuclear Power in Canada

Nuclear technology plays an important role in Canada, and it has done so for more than 70 years. Canada was the second nation to demonstrate controlled fission with the startup of the ZEEP reactor at Chalk River Laboratories. It was one of the first nations to build a demonstration nuclear power reactor, the NPD-2 reactor at Rolphton, Ontario. With the eight nuclear reactors at Bruce, Canada has the world's largest operating nuclear generating facility.

As a Tier-1 nuclear nation, Canada is one of the very few nations of the world in which all of the following activities take place:

- Design of nuclear reactor technology
- Construction and operation of nuclear power plants
- Uranium mining, fuel fabrication and production
- Medical and industrial isotope production
- Decommissioning, environmental remediation and high level, long term waste management
- Full scope nuclear laboratory services and R&D
- Post secondary nuclear education up to doctorate level.

Canada is the second largest producer of commercial uranium in the world, with annual production averaging approximately 10,000 tonnes of uranium consistently over the past 40 years. It has all of the facilities and technology to provide the full spectrum of uranium supply, both to meet Canada's needs and to supply uranium for nuclear power in other nations as well.

The success of Canada's nuclear reactor technology has been shown by its extensive, safe and economic operation in Canada. It has also been acquired by a number of other nations as well, including South Korea, Romania, Argentina and China. In all of these countries, CANDU technology has been shown to be both reliable and economic, providing large quantities of electricity to meet these nations' energy needs. Canada's CANDU technology was also adopted by India and Pakistan, and in the case of India, their heavy water reactor technology is to this day the mainstay of that country's commercial power program.

The following is a list of operating CANDU reactors, both in Canada and around the world.

Table 1: CANDU Nuclear Reactor Performance - 2017

Reactor	In Service	Capacity (MW)	Performance in 2017 (%)	Lifetime Performance (%)
Point Lepreau	1983	705	89.1	70.5
Wolsong 1*	1983	679	40.4	72.6
Wolsong 2	1987	678	90.0	92.4
Wolsong 3	1998	698	32.7	89.9
Wolsong 4	1999	703	99.2	94.0
Embalse	1983	648	0	74.0
Cernavoda 1	1996	707	96.3	90.1
Cernavoda 2	2007	705	89.5	94.0
Qinshan 4	2002	700	76.6	89.8
Qinshan 5	2003	700	94.4	91.5
Pickering 1	1971	542	57.8	64.2
Pickering 4	1973	542	87.8	66.9
Pickering 5	1983	540	63.8	73.6
Pickering 6	1984	540	98.1	78.5
Pickering 7	1985	540	83.0	77.3
Pickering 8	1986	540	85.6	75.5
Bruce 1	1977	825	96.6	68.9
Bruce 2	1978	825	97.4	65.3
Bruce 3	1978	825	83.8	73.5
Bruce 4	1979	825	94.2	73.3
Bruce 5	1985	872	70.3	84.6
Bruce 6	1984	872	80.2	81.9
Bruce 7	1986	872	92.8	84.5
Bruce 8	1987	872	97.7	83.2
Darlington 1	1992	934	60.3	83.6
Darlington 2	1990	934	0	76.0
Darlington 3	1993	934	93.9	86.2
Darlington 4	1993	934	98.7	85.8

https://www.iaea.org/PRIS/CountryStatistics/CountryDetails.aspx?current=CA
Notes
1. Darlington 2 entered plant refurbishment, October 2016.
2. Embalse undergoing plant refurbishment.
3. All reactor performance now based on Load Factor, not Capacity Factor

In total, these reactors have produced more than 3600 TWh of electricity during their years of operation.

From a historical perspective, the only significant change to world electricity production over the past 50 years has been the emergence of nuclear power and to a lesser degree the use of natural gas. The proportion of electricity generated from hydraulic sources in 1950 was roughly similar to the current proportion. However, starting in the late 1950s, nuclear power began to emerge as a major source of new electricity generation. Its impact over the past half-century has been to displace principally oil-fired generation, and to a considerable extent coal-fired generation particularly for base load applications.

To a considerable extent, nuclear and gas complement each other. Nuclear with its high fixed costs and low operating costs works best as base load generation. Gas, with its low fixed costs and high proportional fuel

costs, works best as a peaking power source. (Approximately 90 per cent of the lifetime total cost of a gas-fired CTU comes from fuel purchase and not construction and operation. Nuclear by contrast has much less than 10 per cent of its total lifetime cost in the purchase of fuel.)

For Canada, electricity consumption from all sources was 643 TWh annually. Canada is the seventh largest electricity jurisdiction in the world:

Table 2: World's largest electricity jurisdictions

	Consumption(TWh)
China	6,142
United States	3,166
European Union	3,166
India	1,289
Russia	1,008
Japan	976
Canada	643
Germany	589
Brazil	559
France	536

CIA World Factbook, 2018

Nuclear power remains about 17 per cent of Canada's total electric energy production, above the world average noted above.

Canada however is very different from the large nations.

Table 3: Canada's Electricity Sources

	% share
Hydraulic	63.4
Nuclear	16.6
Coal	14.3
Natural Gas	4.0
Wind	1.5
Other	>0.3

The Canadian Nuclear Factbook 2017, CNA

Canada has more than half its electricity produced by hydraulic energy, whereas the dominant form of generation for all of the other large nations is coal. With approximately 80 per cent of Canada's electricity supply coming from hydraulic and nuclear energy, Canada has one of the cleanest large electricity systems in the world. There has been some new hydraulic construction over the past 40 years, principally the La Grande generating complex in Quebec. But the vast majority of new electric generation in Canada over those 40 years was nuclear power.

It is reasonable to draw several conclusions:

1. That Canada's nuclear power stations have absorbed most of the growth in electricity production over the past half-century; and
2. That Canada's nuclear power stations have displaced fossil fuels in Canada, principally coal and oil; and
3. That 80 per cent of Canada's electric generation is free of atmospheric emissions from the point of generation.

It should be noted that Canada is the only nation in the world, with all of the above-mentioned aspects of nuclear technology and infrastructure, which has developed its nuclear industry for purely peaceful purposes.

II Nuclear Power in Ontario

Ontario is home to all but one of Canada's 19 operating nuclear power reactors. These reactors are concentrated in two main areas: Durham Region with the Pickering and Darlington nuclear power stations; and Bruce County with the Bruce nuclear power station.

Of all of the provinces in Canada, Ontario's electricity system has perhaps the greatest diversity of electricity sources . Nuclear generation is only one part, albeit the most significant part in terms of percentage share, of a large system producing and distributing electricity from a variety of sources:

Table 4: Ontario's Electricity Production – 2017

	Energy(TWh)	%Share
Nuclear	90.6	63
Hydro	37.7	26
Gas	5.9	4
Wind	9.2	6
Biofuel	0.4	<1
Solar	0.5	<1

http://www.ieso.ca/en/corporate-ieso/media/year-end-data

Importance of Bruce NGS in Ontario's electricity supply

The Bruce nuclear power station consists of eight operating reactors, with the performance characteristics shown below:

Table 5: Performance of the Bruce Reactors in 2017 and Lifetime

Reactor	In Service	Capacity (MW)	Performance In 2017 (%)	Lifetime Performance (%)
Bruce 1	1977	830	96.6	68.9
Bruce 2	1978	830	97.4	65.3
Bruce 3	1978	830	83.8	73.5
Bruce 4	1979	830	94.2	73.3
Bruce 5	1985	872	70.3	84.6
Bruce 6	1984	891	80.2	81.9
Bruce 7	1986	872	92.8	84.5
Bruce 8	1987	872	97.7	83.2

https://www.iaea.org/PRIS/CountryStatistics/CountryDetails.aspx?current=CA

On a continuing basis, Bruce Power's eight reactors supply about 40 per cent of the province's total electricity requirement. It should be noted that for the past decade annual performance of the Bruce reactors is significantly higher than lifetime performance. This means that generally the Bruce power station is improving performance with age, rather than the reverse.

It is the view of the CNS that this mid-life improvement in performance is a testament to the investment Bruce Power has made in plant and equipment, personnel and training.

III The Safety Record of CANDU Reactors at Bruce Power

It has become axiomatic in the operation of nuclear power facilities that strong performance with respect to safety is essential to allowing strong production performance. This is true not just in Canada for CANDUs but for all other types of nuclear power reactors around the world. A strong safety performance comes from a large number of factors:

- Nuclear safety culture
- Plant training and human performance

- Attention to plant maintenance, elimination of maintenance backlogs, and focus on ageing and obsolescence management
- Strong coordination for various aspects of safety and plant operation with local communities and governments
- A strong research, technical and industrial support base
- An effective, independent nuclear regulator.

It should be noted that in general, CANDU technology has a record of safety performance second to none throughout its more than half-century history in operation. At no time has any worker been killed or injured by exposure to radiation. And at no time has any member of the public been exposed to any significant radiation release from any CANDU reactor anywhere in the world. The eight reactors of Bruce Power are a key part of that record.

Nuclear power is in fact the safest possible way to generate electricity on any large scale particularly when measured in terms of loss of life or injury as a result of plant operations.

Nuclear safety is not achieved in isolation. It is accompanied by other highly related performances such as industrial accident rate. The Commission should note that the Lost Time Accident (LTA) rate for Bruce Power was approximately 0.05 accidents per 200,000 hours worked. This low LTA rate has been maintained for the past 15 years.
http://nuclearsafety.gc.ca/eng/the-commission/hearings/cmd/pdf/CMD18/CMD18-H41A-Presentation-from-Bruce-Power-Licence-Renewal-for-Bruce-A-and-B-NGS.pdf

It should be noted that workplace safety performance in Canada's nuclear industry and Bruce Power runs strongly counter to overall industrial safety trends in Canada.
http://www.safethink.ca/resources/pdf/Canadian%20Workplace%20Injury%20and%20Fatality%20Facts.pdf

These figures should not be taken as criticism of Canada's overall industrial safety record. With an LTA rate of less than one, Canada's industrial environment remains one of the safest in the world. What it does show is that the nuclear industry in Canada has a safety record unmatched in Canada by any other industry. In fact, there are clear differences between nuclear safety culture and safety culture generally within Canada's or essentially any other industrial system. And these differences extend to all aspects of safety, not just the safety of the reactor core and radiation protection.

With respect to radiation safety, Bruce Power has reduced collective exposure by 2 Sv over the past two years. Over the term of the current operating licence, Bruce Power has reduced personal contamination events to 0.4 events per outage day since 2013. In particular, improvements to pressure tube inspection have produced reductions in collective dose by 200 mSv per outage.

In short, improvements in radiation and workplace safety have gone hand in hand with improvements in overall electricity production at Bruce. It is the view of the CNS that improvements in safety of all kinds is a central contributor to improvements in economic performance.

As noted by the Association of Workers Compensation Boards of Canada, the fatality rate for Canada's industrial workers varied between 750 and 1100 fatal injuries annually between 1993 and 2005. This number does not include fatalities not covered by workmen's compensation, such as farm labour. The Association further noted that there was a generally rising trend over the years. By contrast, the fatal accident rate for workers at Bruce Power and Canada's nuclear workers generally has been zero.

When looking at Canada's industrial sectors, the electricity industry is one of the safest overall with an LTA (Lost Time Accident) average of about 0.7 (hours lost per 200,000 hours worked). By comparison, mining in Canada has a typical LTA of approximately 2.0, and forestry about 2.25. Relatively safe as the electricity industry in Canada is, with an LTA of about than 0.7, Canada's nuclear plants including Bruce Power are more than an order of magnitude less than that. Bruce Power's LTA has generally been at or below 0.05 since 2004. *[Bruce Power Inc., Application to renew the Power Reactor Operating Licence for*

the Bruce A and B Nuclear Generating Stations, Public Hearing Part One, February 5, 2015, p. 10] With such a low LTA rate, common workplace injuries in plants such as that of Bruce Power are a very tiny fraction of Canada's overall industrial accident rate. It can reasonably be said that Canada's nuclear power plants, are perhaps the safest places in the country in which to work.

The importance of such a low industrial accident rate cannot be understated. It comes from highly developed plant procedures, continued investment in personnel training and procedures, and strict attention to detail. It can be reasonably stated that the safety culture of nuclear facilities such as Bruce Power could and should serve as a model for Canadian industrial activity generally.

Larger aspects of nuclear safety in terms of avoiding radiological accidents and preventing public radiation exposure can therefore be seen as a function of an overall safety culture that reduces the incidence of injury from all causes.

IV Major Component Replacement Program

Bruce Power will be commencing its Major Component Replacement Program in 2020. The program will start with the outage of Unit 6 to refurbish the reactor. It will include the replacement of pressure tubes and fuel channels, and replacement of large components such as steam generators. The program will then continue with refurbishment of major components at all Bruce reactors Units 3-8. It should be noted that Bruce Power completed refurbishment of Units 1 and 2.

When complete, the program will extend the operation of the Bruce Power complex to beyond 2060.

The CNS observes that Bruce Power gained valuable experience with its successful completion of refurbishment of Units 1 and 2. Our Society therefore accepts that the schedule proposed by Bruce Power for the completion of its remaining six units is realistic and achievable.

Bruce Power has applied for a 10-year term for renewal of its operating licence. The CNS notes that such a term would be beneficial to both Bruce Power and the CNSC. With a 10 year term, the regulatory requirements for operation of the station's various activities would be consistent and well understood throughout the period under which much of the component replacement program will take place, and provide regulatory certainty for the investors in the replacement program. Consistency in regulatory requirements with the operating licence will contribute strongly to confidence in what the expectations of the CNSC are and will be during this extensive program.

For its part, the CNS expects that Bruce Power will continue its outstanding safety performance throughout this program. Our observation is based in large part on the safety performance improvements that Bruce Power has maintained throughout the past 15 years, which included two reactor refurbishments at Unit 1 and 2.

The CNS observes that Bruce Power and Ontario Power Generation (OPG) have taken a large number of steps over the past five years to coordinate their activity. At this time, OPG is engaged in refurbishment of the Darlington reactors. The refurbishment of Darlington Unit 2 commenced in October 2016, and OPG has received permission this year to continue its program with Unit 3. The two utilities will be proceeding with their programs concurrently, and the CNS notes with approval the high degree of coordination the two utilities have adopted in scheduling their activities with the various industrial suppliers to ensure that project demands can be met. For example, the CNS notes that the Canadian industry has become an international home to the global issue of managing obsolete components within aging nuclear plants. In some respects, the global nuclear industry is now managing its obsolete components on a global basis, not just on a site basis as was formerly the case.

Conclusions

The CNS is therefore of the view that operation of the Bruce nuclear power station must continue, provided that it meets all of the safety requirements of the CNSC. Our reasons are as follows:

1. Nuclear power is essential to Ontario for the supply of base load electricity that cannot be provided economically from any other available source.
2. Electricity supplied by Bruce is an essential part of that base load electricity supply, meeting 30 per cent of Ontario's total electricity demand.
3. Any premature loss of generation from Bruce cannot be met in the short term by either construction of new generating facilities or by increased imports from other jurisdictions.
4. Bruce Power has demonstrated in dialogue with the CNSC a strong response in emergency preparedness and in investment in equipment and personnel.
5. Bruce Power constitutes a strong ongoing source of high technology employment for engineers and skilled trades, providing a solid base for both Ontario industrial capacity and Ontario's academic and apprenticeship training programs.
6. Continuous performance improvement is intrinsic to Bruce Power's nuclear operations, and has been recognized internationally as such.
7. Provision of a 10-year operating licence will add certainty and reliability of regulatory requirements during the Major Component Replacement Program.
8. For more than 15 years, Bruce Power has demonstrated a strong and improving record in radiation and workplace safety.

Therefore, the Canadian Nuclear Society strongly supports the application by Bruce Power for the renewal of its operating licence for the Bruce nuclear power station.