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

Application by Bruce Power
To renew for a five year term and to merge
The operating licences for the Bruce Nuclear Generating Station
(Ref 2015-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 five areas of interest with respect to the continued operation of the Bruce station:

- The strong continued safety record of all CANDU reactors;
- The extensive public outreach program conducted by Bruce Power;
- Emergency preparedness;
- Changing demographics of the Bruce work force; and
- The importance of nuclear reactors to public health.

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. It is the purpose of this paper to provide 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 professionals, scientists and other researchers, 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.

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 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. And 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 I: CANDU Nuclear Reactor Performance
December 2013

Reactor	In Service	Capacity (MW)	Performance In 2013 (%)	Lifetime Performance (%)
Point Lepreau	1983	680	72.6*	70.9
Wolsong 1	1983	622	0*	86.3
Wolsong 2	1997	730	83.7	93.5
Wolsong 3	1998	729	92.6	94.8
Wolsong 4	1999	730	90.2	95.7
Embalse	1984	648	63.3	83.1
Cernavoda 1	1996	706	99.4	90.3
Cernavoda 2	2007	705	89.1	93.9
Qinshan 4	2002	700	92.2	91.2
Qinshan 5	2003	700	102.2	92.3
Pickering 1	1971	542	46.2	63.7
Pickering 4	1973	542	86.2	66.3
Pickering 5	1983	540	58.1	73.5
Pickering 6	1984	540	67.6	78.5
Pickering 7	1985	540	95.1	78.5
Pickering 8	1986	540	86.4	76.8
Bruce 1	1976	825	82.1	75.5
Bruce 2	1977	825	87.7	75.1
Bruce 3	1978	750	86.6	64.6
Bruce 4	1979	750	65.1	64.4
Bruce 5	1985	872	89.7	84.6
Bruce 6	1984	872	79.5	81.4
Bruce 7	1986	872	97.9	85.0
Bruce 8	1987	872	79.0	82.5
Darlington 1	1992	934	97.3	85.6
Darlington 2	1990	934	67.2	78.8
Darlington 3	1993	934	95.8	87.0
Darlington 4	1993	934	68.4	85.9
Total/Average		20,666	79.3	81.8

COG CANDU/PHWR Performance Indicators, December 2013.
**These reactors were under reconstruction during part or all of 2013.*
All capacities in all tables are quoted in gross generation unless otherwise indicated.

In total, these reactors have produced more than 3200 TWh of electricity during their years of operation. To put that in perspective, the *OECD 2011-12 Factbook* notes that based on 2009 figures world total electricity production from all sources was:

Table II: 2009 World Electricity Production

	Capacity(GW)	Energy(TWh)	Share(%)
Coal	942.6	8263	41
Oil	126.7	1111	5
Natural Gas	490.7	4301	21
Hydro	375.1	3288	16
Nuclear	311.6	2731	13
Other	64.8	568	3

OECD/NEA Factbook, 2010-11

From a historical perspective, it should be noted that 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 that above. 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 is approximately 550 TWh annually. Canada is the seventh largest electricity jurisdiction in the world:

Table III: World's largest electricity jurisdictions

	Consumption(TWH)
China	4940
USA	3886
Russia	1016
India	906
Japan	858
Germany	607
Canada	550

CIA World Factbook, 2008

Canada's nineteen operating nuclear reactors, therefore, have produced the equivalent of approximately six years of Canada's total electricity production from all sources or about 18 months of world annual nuclear production. 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 IV: Canada's Electricity Sources

	% share
Hydraulic	62.7
Nuclear	17.08
Coal	14.33
Natural Gas	4.52
Wind	1.46
Other	>0.05

The Canadian Nuclear Factbook 2012, CNA

Canada has more than half its electricity produced by low cost 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 that period 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.

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.

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 of any province in Canada. Nuclear generation is only one part of a large system producing and distributing electricity from a variety of sources:

Table V: Ontario's Electricity Production – 2014

	Energy(TWh)	%Share
Nuclear	94.9	62
Hydro	37.1	24
Gas	14.8	10
Wind	6.8	4.0
Coal	0.1	<1
Other	0.32	<1

http://www.ieso.ca/Pages/Power-Data/Supply.aspx

Importance of Bruce NGS in Ontario's electricity supply

At this time, the Bruce nuclear power station consists of eight operating reactors. The performance characteristics of these reactors are shown below:

Table VI: Characteristics of the Bruce Reactors

Reactor	**In Service**	**Capacity (MW)**	**Performance In 2013 (%)**	**Lifetime Performance (%)**
Bruce 1	1976	825	82.1	75.5
Bruce 2	1977	825	87.7	75.1
Bruce 3	1978	825	86.6	64.6
Bruce 4	1979	825	65.1	64.4
Bruce 5	1985	872	89.7	84.6
Bruce 6	1984	872	79.5	81.4
Bruce 7	1986	872	97.9	85.0
Bruce 8	1987	872	79.0	82.5
		6788	**84.4**	**78.1**

COG CANDU/PHWR Performance Indicators, December 2013.

On a continuing basis, Bruce Power's eight reactors supply about 40 per cent of the province's total electricity requirement.

Important Aspects of the Bruce Power NGS

We have discussed above the overall importance of the Bruce nuclear reactors to Ontario's electricity supply. The CNS now wishes to discuss five additional considerations with respect to the importance of continued operation of the Bruce nuclear power station.

I The Safety Record of CANDU Reactors

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

It should be noted that in general, CANDU has a record of safety performance second to none throughout its half-century history. 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 0.05 accidents per 200,000 hours worked.

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

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.

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 which to work.

The importance of such a low industrial accident rate cannot be understated. It comes from highly developed plant 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.

II Public outreach and Bruce Power

A large part of the successful operation of any facility are the interconnections between the facility and its host community. It has been found generally not sufficient to indicate that "our doors are always open". Modern industrial operations must continually reach out to the surrounding community actively and continually. And it's not merely a matter of communications either. Industries, of which the nuclear industry is no different, are being hosted by and are therefore an integral part of any community. It means that the industry must participate in the life and economy of its local host community.

The CNS was particularly interested in the full range of activities in which Bruce Power sponsors, participates in and supports within its local municipalities and in Bruce, Grey and Huron Counties as a whole. These have been documented in their ongoing activities both in their proponent's submission to the CNSC and much more broadly on the Bruce Power website. And they are fostering strong contacts and good relations with their host communities as an ongoing operation of their business, not just because they need some decision from local citizens or because there is some current difficulty.

It should be noted that Bruce Power is expanding its activity within the community over time. As one example, 9/11 compelled a large number of changes to public access to Canada's nuclear facilities with greatly increased security requirements. This was immediately adverse to Canada's industry, as many forms of public interaction with the plants were curtailed. One such interaction was the relative ease of plant access by the public in former, pre-9/11 times. It is gratifying to note that Bruce Power has revived a program of plant bus tours during 2014.

Bruce Power has six major areas of concentration in communications:

- Employees and pensioners;
- Communities around the site;
- First Nations and Metis;
- Government stakeholders;
- Media and investors;
- Other stakeholders

Details of these various programs are found in the *Bruce Power Communications Report, February, 2015*. It is the view of the CNS that Bruce Power's communications program is both sustained and growing over time. The results of these efforts are that the operations of Bruce Power are supported strongly by governments, local media, and the general public.

III Emergency Preparedness

Emergency preparedness has assumed much greater importance for all industrial operations, not just nuclear, since the Fukushima earthquake and tsunami of 2011. Emergency preparedness has at least two dimensions: consideration of specific ruggedness and reliability of plant equipment as well as the training and skill of the plant workforce; and coordination with the local host community in the event of a plant emergency.

It is clear to the CNS from the proponent's submission on Day 1 of these hearings and from the response by CNSC staff to the submission that Bruce Power has indeed thought extensively about emergency preparedness in the wake of events in Japan in 2011. It is equally apparent that both Bruce Power and the CNSC have come to agreement on steps to be taken to enhance emergency preparedness and the schedule

by which these steps would be implemented. And these steps were not taken in isolation but as part of a far larger global response by nuclear industries and regulators.

These steps include:

- Five new dedicated fire pumper trucks to cool fuel both in reactors and spent fuel bays;
- A new Emergency Management Centre with its own independent power supply;
- Greatly enhanced plant communication systems including its own dedicated AM broadcast capability, point-to-point radio communications, and a tested FM system to broadcast alerts;
- Development of a clear and efficient chain of command under its Incident Management System;
- 10 new portable generators;
- Installation of dry hydrants to use lake water for emergency cooling purposes;
- Full analysis of maximum lake water levels;
- Enhanced training for emergency conditions.

Details of these steps are outlined in http://www.brucepower.com/wp-content/uploads/2012/09/Post-Fukushima-Improvement.pdf
The effect of these and many other steps has been to reduce the dependency of Bruce Power on external sources and to ensure a safe state in the event of on-site power loss. The problems at Fukushima-Daiichi came from vulnerability to flooding and complete loss of internal plant communications. The steps noted above taken by Bruce Power working with the CNSC will mitigate or avoid replication of any such problems at Bruce as experienced at Fukushima-Daiichi in 2011.

It is the view of the CNS that Ontario's citizens have been well-served thus far by the millions of dollars and thousands of man-hours that have been spent on enhancing Bruce Power's capability to respond successfully to emergency conditions.

IV Changing Demographics

In its submission to the CNSC, Bruce Power placed one sheet of great importance before the Commission which is worth restating here.

Age	2001	2014
>36	316	1351
36-45	1265	1018
46-55	1376	1245

During those 14 years, Bruce Power also experienced 1700 retirements from its existing work force. Also during those 14 years since it assumed control of the plant, it has expanded from about 2800 to 3600 employees.

This is highly significant for both Bruce Power and Canada's nuclear industry generally. For 14 years, Bruce Power has been and continues to be a source of demand for new professional engineering and skilled trades workers. This is ensuring that Bruce Power is renewing its workforce and maintaining the necessary skill sets required for plant operations and ensuring that they are in fact being passed on to a new generation of plant workers.

It should be remembered that with total employment of about 3600, Bruce Power is in fact one of the largest employers in Ontario. What it does in terms of attracting and growing its workforce and their skill set matters deeply to both the rest of Canada's nuclear industry and to Ontario's overall economy. By creating and maintaining strong conditions for workplace growth and career opportunities, Bruce Power in turn encourages academic institutions to maintain nuclear physics and nuclear engineering programs. It encourages industry to maintain employment in these same skill sets, along with a host of skilled trades, to serve the needs of Bruce Power in its ongoing operations.

Bruce Power is thus a large part of Ontario's high technology future. And it is supporting in large part the education and skill training on which nuclear agencies such as the CNSC depend for proper and comprehensive regulation of the industry.

The Nuclear Renaissance is indeed here, and in the view of the CNS, it is manifesting itself in the new generation of nuclear engineers and operators, both men and women, that has emerged over the past decade.

V Clean Energy – Clean Hospitals

The importance of Bruce Power to the future of Canada's public health is considerable and growing. Bruce Power signed an agreement with Nordion in November, 2014 for the long term supply of Cobalt-60. This supply agreement runs for up to 14 more years into the future, and it affects the health of people around the world as well as those in Canada.

Cobalt-60 is an essential part of modern health procedures. It enables complete sterilization of materials including those which cannot be sterilized by older methods of steam autoclaves. Canada supplies Cobalt-60 to more than 200 gamma irradiators in 55 countries around the world. The availability of this technology has become even more important in recent decades with the emergence of infections resistant to antibiotics.

The World Health Organization (WHO) notes that about 640,000 surgical procedures are performed each day. Virtually all of these use equipment sterilized by gamma irradiators, and Canadian-supplied cobalt is essential to maintain the integrity of these operations on a daily basis. With no hazardous atmospheric emissions, nuclear power is indeed clean energy, and that clean energy produces the materials which make clean hospitals possible.

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. Because of supply from Bruce Power, Canada will remain a large source of the world's supply of Cobalt-60.

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