



Oral Presentation

Submission from the Society of Professional Engineers and Associates

In the Matter of

**Ontario Power Generation Inc.,
Pickering Nuclear Generating Station**

Request for a ten-year renewal of its Nuclear Power Reactor Operating Licence for the Pickering Nuclear Generating Station

Commission Public Hearing – Part 2

June 2018

Exposé oral

Mémoire de la Society of Professional Engineers and Associates

À l'égard de

**Ontario Power Generation Inc.,
centrale nucléaire de Pickering**

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 Pickering

**Audience publique de la Commission –
Partie 2**

Juin 2018



SPEA

Society of Professional Engineers and Associates

Pickering NGA Application for License Renewal

Dr. Michael Ivanco – Past President SPEA



CNSC

June 26-28, 2018

Background

- The Society of Professional Engineers and Associates (SPEA) is a union that represents engineers, scientists, technicians, technologists, designers and skilled trades who work for SNC Lavalin's Nuclear Division.
- Formerly our members worked for the reactor division of Atomic Energy of Canada Ltd, which was the designer of the Pickering A reactors and designer of CANDU 6 reactors around the world.
- Our members currently design reactors and provide engineering, technical and procurement support for existing reactors around the world and in Canada, including those at Pickering NGS

Role of the Pickering NGS in Ontario (1)

- The Pickering A reactor units were the first multi-unit electricity producing nuclear reactors built in Ontario and were commissioned between 1971 and 1973. The first unit to be commissioned (Pickering A Unit 1) is still on operation, following refurbishment.
- For many years the Pickering A units were amongst the very best operating stations in the world.
- Through the 60s, 70s and 80s the Ontario's economy was expanding and in need of abundant and cheap electricity. With the easily exploitable hydro electric capacity already developed this meant building coal or nuclear.

Role of the Pickering NGS in Ontario (2)

- The Ontario government chose to build both types of electricity generation. The nuclear generation built at Pickering, then at Bruce NGS and later at Darlington replaced, on a one-for-one basis, generation that would otherwise have been produced by burning coal.
- Burning 1 kg of coal yields approximately 1 kg of Carbon Dioxide (CO₂)
- The Pickering nuclear units have produced over 850 TWh of electricity and, thus, have displaced more than 850 million tonnes of CO₂

Role of The Pickering NGS in Ontario (3)

- Canada's annual emissions from all sources, by comparison, are about 700 million tonnes of CO₂
- Annually the station generates more than 20 TWh of carbon free electricity, enough to power over 1.6 million homes, and avoids 20 million tonnes of CO₂ emissions.
- In 2017 the Pickering NGS satisfied about 16% of Ontario's electricity demand. It plays a key role in powering the homes and industries in and around Toronto, where its proximity is important
- When it shuts down it will leave a gaping hole in Ontario's electricity generating infrastructure

Role of The Pickering NGS in Ontario(4)

- The Pickering NGS has played a key role in reducing Canada's GHG footprint over the years
- It is difficult to imagine a replacement for Pickering that does not also increase Ontario's GHG footprint, though that is not an issue of relevance for the license extension
- Providing reliable 24/7 baseload power is possible, in principle, through a combination of wind power and solar generation supplemented by natural gas. This would be the most benign replacement form of generation but replacing Pickering with a combination of, say, 25% intermittent renewables¹ supplemented by 75% natural gas would increase the electricity sector's GHG emissions by approximately, 7.5 million tonnes of CO₂ per year, which is like adding 1.5 million cars to the road. (note: 1 – the average capacity factor for wind power in Ontario is approximately 25% and we have assumed 500 g of CO₂ emissions per kWh for Natural Gas-fired electricity generation)

Role of The Pickering NGS in Ontario(5)

- Some of the reactor control adjuster rods in the Pickering reactors are made of Co-59, which activates to Co-60, which is used in radiation therapy machines
- A significant portion of the world's supply comes from the Pickering NGS
- Canada was a pioneer in this field and AECL had a separate business building radiation therapy machines for cancer treatment, until it was spun off to the private sector in the late 1980s.
- The first patient treated using Co-60 was in London, Ontario in 1951

Role of The Pickering NGS in Ontario(6)

- Nuclear generation sites such as Pickering employ large numbers of highly skilled people.” Nuclear generation facilities are unique in this respect.
- For example, fossil fuel natural gas-fired generation facilities and nuclear facilities generate electricity at comparable prices, though nuclear generated electricity is slightly cheaper in Ontario.
- In a natural gas fired plant about 70% of the cost of the electricity is related to the cost of the fuel and a typical large plant will employ about 20 people.
- In a nuclear plant like Pickering, only about 5% of the cost of the electricity is related to the cost of the fuel and a single large plant will typically employ 600 to 700 people.
- The Pickering site, with 6 operating units currently employs about 3,000 people in all areas of science, engineering and technology.

Role of The Pickering NGS in Ontario(7)

- The Pickering NGS has for many years played a significant role in powering Ontario's economy and the site itself provides many high skilled people with employment
- It's closure in 2024 is lamentable for many reasons:
 1. Replacement power will increase Ontario's GHG footprint, at a time when the province and the country are trying to reduce emissions from all sources, including transportation and home heating
 2. Baseload generation, which Pickering currently provides, will increase steadily in the future as we electrify the transportation sector. For example, if 5% of the light vehicle fleet in Ontario is electrified, baseload demand increases by about 400 MW. Given that the eventual goal is complete electrification this would require about 8000 MW of additional baseload – and none of this considers home heating fuel replacement. Electrification of transportation does not make much sense if electricity is supplied by fossil fuels.
 3. A refurbishment of Pickering would create over 3,000 MW of GHG emission free baseload power for 45 or more years. We realize that this has been considered by OPG and has not been recommended but we suggest that economic and other evaluation factors may have changed since that assessment

Key Factors for Consideration in Licence Renewal

- Robustness of Design
- Safety Performance
- Environmental Performance
- Safe Management of Used Fuel

Robust Design (1)

- CANDU reactors are unique, compared to conventional pressurized light water reactors, be they Westinghouse type PWRs or GE type Boiling water reactors.
- Fuel is non-enriched and unused fuel can be handled, by hand, with no danger.
- CANDU reactors have defence in depth with 5 physical barriers between the radioactive fuel and the environment
 1. Fuel is in a stable UO_2 matrix
 2. The fuel matrix is contained inside a welded fuel sheath that is made into fuel bundles
 3. The fuel bundles are contained inside pressure tubes, where they are cooled by water and the pressure tubes are part of a sealed system
 4. The entire system is contained within an air tight reactor building with walls at least 4 feet thick
 5. The individual reactor buildings are connected to a large vacuum building, which is designed to collect any emissions from a reactor building that could result from an accident.

Robust Design (2)

- The CANDU reactor core is multiplexed, instead of there being one large pressure vessel, so that if there is ever a Loss-of-coolant accident (LOCA), it is likely to be confined to a single channel with no danger to the employees or the public.
- Indeed, there have been small LOCAs at the Pickering station – both involving Pickering A Unit 2.
- In 1982 the G16 pressure tube in Unit 2 ruptured, resulting in a LOCA. However, the leak was well contained, there was no increase in station emissions as a result, and the ECC was not even required to be triggered.

Robust Design (3)

- Nonetheless, the accident investigation revealed two design flaws. One was material selection. The Pickering A reactor fuel channels were made of a Zirconium alloy not used in other reactors, and it was discovered that garter springs around the pressure tubes moved because of vibrations during operation and this movement could increase sag in the horizontal pressure tubes. Tools were developed to reposition these springs in working reactors.
- The other LOCA involving the Pickering station, which also occurred in unit 2, resulted from the failure of an elastomer in a pressure relief valve and subsequent issues that stemmed from that.

Robust Design (4)

- Unlike the 1982 P2-G16 LOCA, there was no breach of the pressure tubes.
- Like the 1982 LOCA, there was some heavy water loss though it was through a relatively small diameter pressure relief line, not due to a pressure tube rupture.
- Again, like the 1982 LOCA there was no exposure to the public
- However, the loss of heavy water coolant was large enough that it triggered the ECC system, for the first time ever.

Robust Design (5)

- Reactivity excursions, in case of any accident, in the reactor core are slow compared to light water design (PWRs and Boiling Water Reactors)
- A number of abnormal operating events in light water reactors, for which safety systems need fast response, are not major issues in a CANDU reactor.
- Control rod ejection, for example, cannot occur in a CANDU because the moderator is not pressurized.
- Main Steam Line break requires immediate action, on the scale of 1 second or less, in a PWR. While it can happen in a CANDU reactivity excursions are on the time scale of minutes rather than fractions of a second.

Robust Design (6)

- Both Pickering A and Pickering B has two independent and fast acting shutdown systems. The first, insertion of shutdown rods, is the same for both designs. Units 1 and 4 employ moderator dump tanks as the secondary shutdown system and the Pickering B units employ the more modern Gadolinium nitrate injection method.
- We presume that it is this difference that results in the Pickering A units having higher CDF and LRF PSA results than the B units, although both are below regulatory limits

Robust Design (7)

- There is an order of magnitude more water in a CANDU reactor, compared to a PWR or BWR, core to act as a heat sink in the event of a beyond design basis accident.
- The “order of magnitude more water” in a CANDU reactor gives it an inherent advantage in situations such as the one that occurred at Fukushima – i.e. station blackout with loss of all power.
- Water buys time because of its high heat capacity and heat of vapourization
- In Fukushima bad things started to happen after about 12 hours.
- If it had been a CANDU reactor instead of a BWR, there would have been at least a couple of days to find an alternative solution for cooling the fuel

Response to Fukushima (1)

- An accident resulting in a complete station blackout is difficult to imagine on the shores of the great lakes. No Tsunami is going to happen here for example
- Nonetheless, the accident caused all reactor designers, operators and regulators to review their designs, operations and regulations.
- The CNSC created an integrated action plan and identified action items that consist of design changes, analysis of robustness of design in beyond design basis accident scenarios and also development of new regulations.
- All original Fukushima action plans were closed for the Pickering site.
- These modifications, in our opinion, go far beyond what is necessary to ensure safety of the facility but should provide the general public with the assurance that OPG and all CANDU operators have more than gone the “extra mile” when it comes to the safety design of the facility.

Safety Performance ⁽¹⁾

- OPG has conducted a Periodic Safety Review (PSR) for the Pickering NGS.
- This comprehensive assessment of the design, current state of the plant, operations and performance is carried out once every 10 years and led to an integrated action plan that identified 63 action items.
- The CNSC found the IIP to be acceptable.

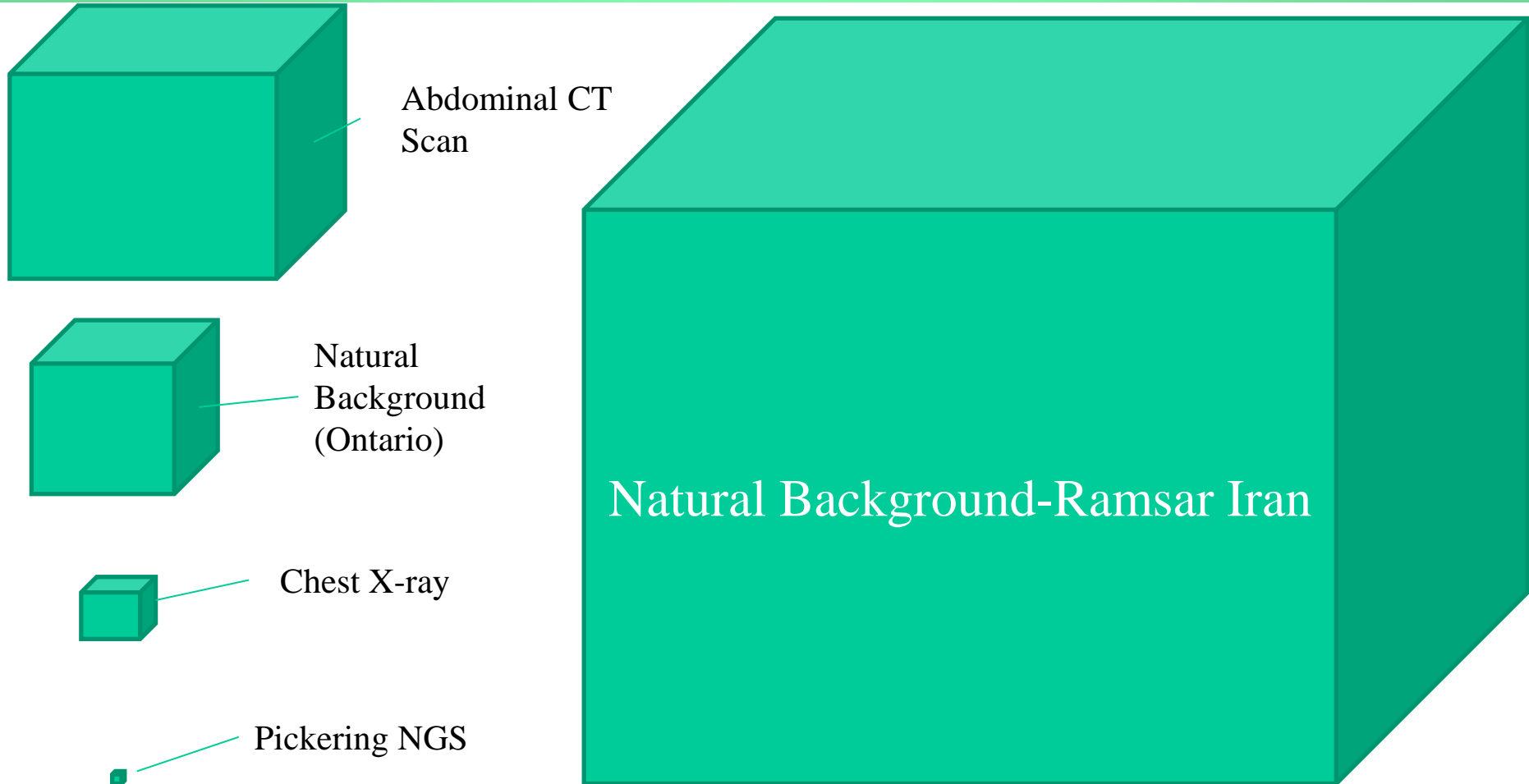
Safety Performance (2)

- The CNSC assessed the performance of the Pickering NGS with respect to 14 safety and control areas, including management of used fuel.
- The performance of Pickering was found to be either satisfactory or fully satisfactory with respect to all of these.
- These factors also give us confidence in the ability of OPG staff to manage the plant safely.

Environmental Performance

- Worker dose at Pickering is well below regulatory limits.
- Dose to the public from operations at Pickering have been in the range 0.9 to 1.5 μSv . At the high range this is 1/667th of regulatory limits. To put this in perspective natural background radiation is about 2000 μSv
- Note that there are places in the world where the “natural” background dose is as high as 260,000 $\mu\text{Sv}/\text{a}$ (more than 173,000 times higher than the radiation dose due to the operations of the Pickering NGS) with no apparent negative impact on health¹.
- Note: 1 – The location referred to is in Ramsar, Iran and the high background is due to Ra-226 and it’s daughter products, brought to the surface by hot springs.

Radiation doses to the public in perspective (1)



License Extension (1)

- Pickering NGS has requested the ability to operate up to 295,000 Equivalent Full Power Hour (EFPH)
- The limiting factor is the lifetime of the pressure tubes
- Analysis and laboratory tests appear to support this request
- The Pickering NGS plays a key role in Ontario's electricity generating system, and will be especially important as the fleets at Bruce and Darlington undergo refurbishment – at least for the first units, since Pickering is slated to be shut down in 2024
- The CNSC approves this request as long as testing supports it and SPEA certainly concurs with this assessment

License Extension (3)

- Pickering is also requesting a license extension that is 10 years long, instead of the shorter periods granted in the past.
- License extensions of this length have been granted, most recently to Chalk River Labs.
- OPG has demonstrated that it is a trustworthy and capable operator and SPEA supports this license extension to the year 2028.
- We note that the units will only be operational for the first 6 years of the license period.

Summary (1)

- Electricity generation by the Pickering plant has avoided, and continues to avoid, large CO₂ emissions that would otherwise be necessary.
- Based on independent measurements, the release of radiation from the operation of the Bruce plant has been consistently low, less than 1/667th of the allowable limit.
- The CANDU reactor design is robust and provides high resistance to accidental release of radiation.
- OPG has done an excellent job in recent years operating and maintaining the Pickering NGS.
- On this basis, SPEA supports OPGs request regarding the plant's operating license extension.

Summary (2)

- At a time when Ontario has had great success in reducing its GHG emissions from the Ontario electricity sector, and has embarked on the same mission for the transportation sector, it will be a shame to see one of Ontario's cleanest electricity generating stations shut down.
- The 4 Pickering B units, for example, could provide enough electricity to power over 1.5 million cars which would reduce GHG emission from the transportation sector by over 7.5 million tonnes.
- But if Pickering is replaced by a combination of natural gas fired electricity and wind power, GHG emissions would go up by the same amount.
- SPEA believes that OPG should reconsider its decision to not refurbish the Pickering B units taking into account socio-economic and environmental factors as well.

Questions



Addendum – Calculation of impact of Automobile electrification on Baseload demand

Assumptions

1. Average vehicle travels 20,000 km per year
2. Average vehicle travels 4.7 km/kWh¹
 - Therefore the average vehicle consumes 11.65 kWh per day
3. There are approximately 7 M light vehicles in Ontario so 5% = 350,000 cars, so 11.65 kWh X 350,000 = 4.07 GWh of extra electricity is needed per day
4. Assume that the vast majority of car charging takes place during 10 overnight. This means that this 4.07 GWh needs to be provided over a 10 hour overnight period, then that means that 407 extra MW of baseload² generation is needed.

Note 1. This value is for a Nissan Leaf, which is a typical electric vehicle

Note 2. Baseload generation is essentially equal to the electricity demand at the lowest demand time – or the early morning hours