Fairewinds Associates, Inc
Arnold Gundersen, Chief Engineer
70 South Winooski, Box 289, Burlington, VT 05401
Phone 802-865-9955
fairewinds@mac.com

ANALYSIS OF THE RELICENSING APPLICATION FOR PICKERING NUCLEAR GENERATING STATION

Durham Nuclear Awareness (DNA) commissioned Fairewinds Associates, Inc to conduct a safety review of the continued operation of the Pickering Nuclear Generating Station (NGS) and propose measures to mitigate or reduce these risks. Fairewinds Associates' Chief Engineer Arnie Gundersen has written this report for submission by DNA to the Canadian Nuclear Safety Commission (CNSC).

CREDENTIALS

My name is Arnold Gundersen, and I reside at 125 Northshore Drive, Burlington, Vermont, USA. I have been employed as the Chief Engineer for Fairewinds Associates, Inc, an expert witness and paralegal services firm located in Burlington, Vermont, USA since its founding in 2003. My updated Curriculum Vitae is attached.

I earned my Bachelor Degree in Nuclear Engineering from Rensselaer Polytechnic Institute (RPI) cum laude. I earned my Master Degree in Nuclear Engineering from RPI via an Atomic Energy Commission Fellowship. The areas of study for my Master Degree were: cooling tower operation and cooling tower plume theory.

I began my career as a reactor operator and instructor in 1971 and progressed to the position of Senior Vice President for a nuclear licensee prior to becoming a nuclear engineering consultant and expert witness.

I serve as an expert witness before the United States Nuclear Regulatory Commission (USNRC) Atomic Safety and Licensing Board (ASLB) and Advisory Committee on Reactor Safeguards (ACRS), in Federal Court, the State of Vermont Public Service

Board, the State of Vermont Environmental Court, and the Florida Public Service Commission.

I am an author of the first edition of the United States Department of Energy (USDOE) Decommissioning Handbook.

As an appointee of Vermont State Legislature for two years, I was charged with serving in an oversight role of Entergy Nuclear Vermont Yankee and an advisory role on nuclear reliability issues to the Vermont State Legislature.

I have more than 40-years of professional nuclear experience *including and not limited to*: Nuclear Power Operations, Nuclear Safety Assessments, Nuclear Power Management, Nuclear Quality Assurance, Archival Storage and Document Control, NRC Regulations and Enforcement, Licensing, Engineering Management, Contract Administration, Reliability Engineering, In-service Inspection, Thermohydraulics, Criticality Analysis, Radioactive Waste Processes, Decommissioning, Waste Disposal, Cooling Tower Operation, Cooling Tower Plumes, Consumptive Water Use, Source Term Reconstruction, Dose Assessment, Technical Patents, Structural Engineering Assessments, Nuclear Fuel Rack Design and Manufacturing, Nuclear Equipment Design and Manufacturing, Public Relations, Prudency Defense, Employee Awareness Programs, and Whistleblower Protection.

BACKGROUND: CANDU REACTORS AND PICKERING NUCLEAR GENERATING STATION (NSG)

1. Like many other reactor designs, the concept for the CANDU nuclear reactors originated during the 1940s and 1950s, and the reactor prototypes were developed during the 1960s. While there were logical scientific reasons why Canadians originally chose the CANDU design, those choices continue to plague the CANDU design today.

   1.1. The scientific reasons Canada chose the CANDU design began with the availability of heavy water as well as the abundance of natural Uranium and no enrichment capability. That decision to use natural uranium in CANDU reactors created myriad design tradeoffs that plague the CANDU design to this day. Chief among these was the need to continuously refuel the reactor because fissile uranium U235 had only an abundance of seven atoms out of every one thousand atoms of non- fissile U238. The need to continuously refuel the reactors created an added level of complexity with an abundance of fuel channels inside the core and a multitude of cooling pipes outside the core area of each nuclear reactor.

1.2. Worldwide there are approximately 440 nuclear plants in operation today. Of this group, only 29 are of the CANDU design and an additional 13 are CANDU derivatives, for a total of 42. The breakdown by country[1] is as follows:

1.1.1. Canada: 17 (+3 refurbishing, +5 decommissioned)
1.1.2. South Korea: 4
1.1.3. China: 2
1.1.4. India: 2 (+13 CANDU-derivatives in use)
1.1.5. Argentina: 1
1.1.6. Romania: 2
1.1.7. Pakistan: 1

1.3. For whatever reason Canada originally chose the CANDU design, it is apparent from the data that the most other nuclear nations have rejected that CANDU design concept. After sixty years of nuclear power designs, less than 6% of the reactor designs worldwide (beyond the borders of Canada) are similar to the CANDU design.

2. Why did most of the world reject the CANDU design?

2.1. The choice to use natural uranium made for an extraordinarily large and complicated nuclear core structure that is filled with very expensive and difficult to obtain heavy water. This unique combination of complicated nuclear core structure and heavy water has increased the costs of the CANDU design.

[1] http://www-pub.iaea.org/mtcd/meetings/PDFplus/2009/cn164/Sessions/09KS_ALIZADEH%20CANDU%20Technology%20IAEA%20Oct%202009.pdf

2.2. Throughout most of the world, the complex structure of the CANDU design has been rejected for the intricacy of its fuel channels and piping design.

2.3. In order to eliminate complexity and risk, trends worldwide have been to move reactor pumps and piping inside the reactor vessel itself. Elimination of external pipes reduces the chance of pipe breaks and reduces the likelihood of an accident. In other designs used throughout the world, the simplification of the piping systems has lead to less complexity, higher reliability, and improved safety margins.

2.4. The separation of coolant and moderator has created a positive void coefficient of reactivity -- an undesirable characteristic from a reactor safety point of view, unique to pressure-tube reactor designs such as the CANDU and the RBMK, the Russian design used at Chernobyl.

2.4.1. *A positive void coefficient of reactivity* means that the nuclear chain reaction speeds up whenever there is a loss of coolant accident. This is undesirable because under adverse circumstances, a loss of coolant accident may be compounded by a loss of regulation as well (a power surge).

2.4.2. When the coolant is lost in a CANDU reactor, the moderator remains intact, so the nuclear reaction increases because there is an increased availability of thermal neutrons when steam forms in the primary cooling circuit.

2.4.3. So, under accident conditions, the heat increases in the nuclear core creating more power, not less. Thus *a positive void coefficient of reactivity* is a much more dangerous design, like having a car engine accelerate at the same time one is trying to apply the breaks.

2.4.4. The CANDU design does not meet international expectations for a more passively safe nuclear reactor design. In most other reactors, such as those used in the US and throughout the world, there is a negative void coefficient of reactivity -- meaning the power level drops when the coolant is lost. That's because the coolant and the moderator are the same in those reactor designs, so as soon as the coolant is lost the moderator is also lost and the chain reaction quickly comes to a stop.

2.4.5. The inherent complexity of the fuel channels and piping design used at the Pickering NGS, together with the positive void coefficient of reactivity, have been judged to be sufficiently undesirable throughout most of the world to prevent the adoption of CANDU technology in all but a handful of countries.

3. Simply put, the fuel channels and associated pressure tubes of the piping design in the Pickering nuclear reactor were created by decisions made almost 50 years ago leaving an underlying design concept has reached the end of its useful life.

   3.1. As the reactor ages, it becomes increasingly difficult to determine the status of all of the individual components, and so the safety case becomes increasingly uncertain as it is necessarily based upon incomplete and questionable data.

4. Pickering's CANDU reactors were built as a multi-unit station. *These six nuclear reactors at Pickering share a single common safety system:* the vaccuum building.

   4.1. This shared safety system leads to a reduced redundancy that significantly compromises nuclear safety. One of the hallmarks of nuclear power is that *each unit has its own back-up and redundant safety systems*, so that if one system fails, there is another safety system in place to take over thereby protecting public health and safety.

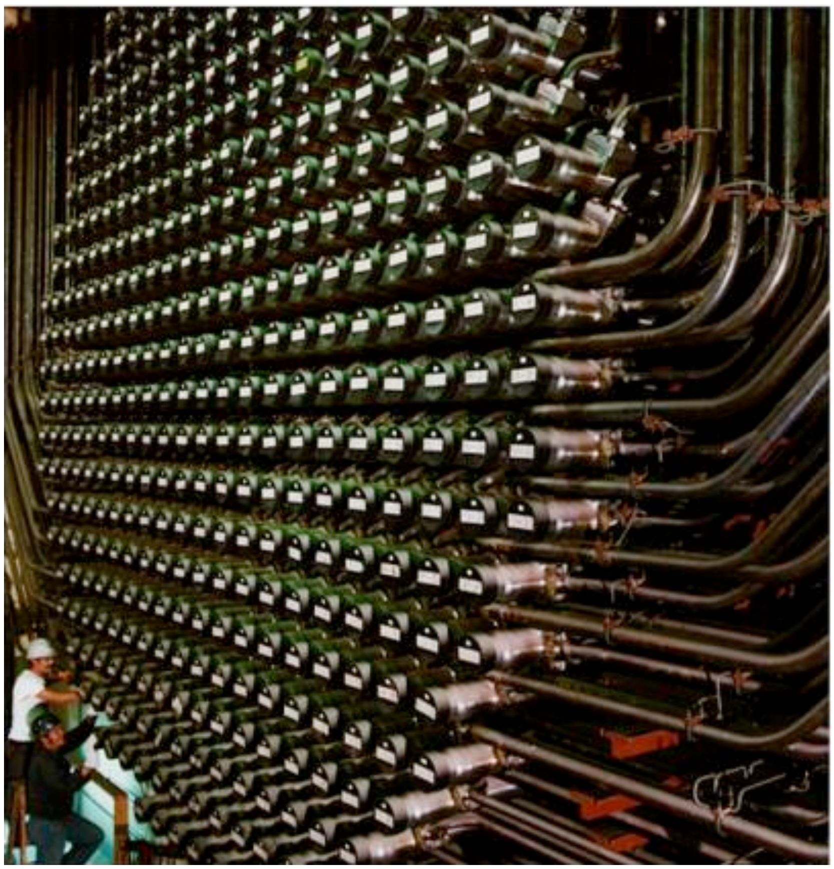
   4.2. At the Pickering site, there is only one overall *safety related containment* system when there should be *six separate safety related containment* systems. This design flaw has created a cumulative risk at the Pickering station that is higher than that at any single unit station in Canada.

PRESSURE TUBE AND FUEL CHANNEL PROBLEMS AT PICKERING

5. CANDU reactors like Pickering have a long, well documented history of problems with their pressure tubes and fuel channels. The complexity of these components and

the severe environment in which the components are forced to operate are leading factors in CANDU's unreliability when the plant has aged and components are deteriorating.

6. This picture[2] inserted below begins to illustrate how the cooling pipes and refueling fittings are enmeshed in a warren of pipes and connections interacting in the Reactor Face of a typical CANDU reactor.



6.1. Canadian nuclear scientist F.R. Greening, Ph. D. has succinctly identified the pressure tube problems in the CANDU Pickering design in a publicly available report that summarizes the problems with the CANDU Pickering pressure tubes. Dr. Greening said,

> Pressure tube problems have plagued CANDU reactors since the early days of Pickering NGS in the mid l970s. OPG, NBP, AECL

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[2] http://3.bp.blogspot.com/-TI583uRsicU/T1eZ8RZchqI/AAAAAAAAACo/o_y1Tc7SLpw/s1600/Reactor_Face.png

and other members of COG, the CANDU Owners Group, have collectively spent over $100 million on pressure tube research and development in the past 20 years but achieved ***only marginal improvements*** in pressure tube performance…

One would expect that after OPG and AECL fixed all these early problems, CANDU pressure tubes would now be able to deliver many years of trouble free service. Indeed, the CNSC stipulates that nuclear pressure boundary materials meet stringent inspection codes as a licensing requirement.

Unfortunately, the complexity and ***inconsistent results*** of pressure tube inspections over the past 25 years leave the question of future CANDU ***pressure tube performance still very much in doubt***….

These observations raise ***serious concerns*** about the reliability of the inspection procedures used for pressure tubes at Bruce, and undermine any belief in the long-term integrity of pressure tubes in all CANDU reactors. Certainly, as a veteran of many years of research into pressure tube corrosion and hydrogen pickup, I can attest to the ***poor level of mechanistic understanding*** of pressure tube behavior inside a CANDU fuel channel in spite of the efforts of literally hundreds of scientists and engineers worldwide.

A good example of an observation ***lacking a cogent explanation*** is the remarkable variability, frequently by more than a factor of two, in the rate of corrosion and deuterium uptake by nominally identical pressure tubes sitting side by side in a reactor.

The through-wall distribution of deuterium is ***another mystery***…. the CANDU reactor design incorporates a number of intricately engineered and ***highly complex systems*** that require an ***inordinate amount of skilled manpower*** to operate, inspect and repair.

Many components are ***difficult to access***, or are located in areas of high radiation fields, ***adding to the problems of CANDU reactor operation and maintenance***…

Unfortunately, as Ontario's CANDU reactors approached 20 years of operation, ***serious problems with critical components started to emerge***. Pressure tube integrity became a major issue in the 1980s, while steam generator corrosion and annulus gas problems dominated the l990s. Outlet feeder pipes are the latest CANDU components to ***suffer from premature failures.***

> The hard pill for AECL to swallow is that CANDU's innovative engineering, seen as leading edge in the 1960s, has become ***its Achilles' heel*** by the year 2000. This is perhaps not so surprising for 50 year-old technology. After all, many engineering marvels from the 1960s, such as the Space Shuttle and Concorde, have now outlived their usefulness as recent events have so dramatically shown.
>
> But, to return to the main thesis of this submission, ***CANDU was destined to run into difficulties due to the complexity of its design***. Corrosion is a well-known concern for all nuclear plant, but when it occurs in essentially inaccessible pipe work, such as the annulus gas system, it presents a problem that is next to impossible to fix.
>
> As we have shown, each new problem that developed in CANDU reactors - whether it was leaking pressure tube rolled joints, annulus gas system flow blockages or feeder pipe thinning - has required more inspections leading to more outages and higher OM&A costs.
>
> The CANDU reactor was always an experimental venture; it has had its successes and was probably a worthwhile undertaking because it added to our understanding of nuclear science and engineering. ***However, it is time to declare the CANDU experiment over, and move on to something simpler, something proven, something better.***[3] [Emphasis added]

6.2. Furthermore, in a second report, Dr. Greening argues that the Canadian engineering expertise to adequately design CANDU reactors is no longer available. He said,

> I believe AECL's predicament with regard to the Maple X reactor stems from the fact that, in spite of a 50-year legacy of building nuclear reactors, this once great engineering company has ***lost most of its expertise*** in reactor design.
>
> Many of the CANDU reactors operating in Ontario today were designed in the 1960's, other, newer, reactors commissioned in Ontario in the 1980's or early 1990's, are essentially old AECL designs modified by OPG's Design and Development Division. … And AECL can no longer turn to OPO for help in designing new reactors because OPG ***also lost its expertise*** in this area when it disbanded its own Nuclear Design and Development Division back in theI990's.[4]

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[3] http://www.energyquest4nanticoke.ca/green1.htm
[4] http://www.energyquest4nanticoke.ca/green2.htm

6.3. The CNSC itself set forth a criteria for adequacy of design of safety related structures and components at the Pickering Nuclear Generating Station. In its response to OPG's Initial Response to CNSC, the CNSC stated:

> E.2 CNSC staff recommends OPG should demonstrate safe operation for a minimum of 10-year period beyond the assumed design life, if ever required.[5]

7. At the same time that the CNSC is requiring demonstrated safety for ten years beyond the unit's designed operating life, OPG seems to have applied a double standard to fuel channel integrity as evidenced by the following excerpt from its *Fuel Channel Life Management Project*:

> As Pickering B approaches its current nominal operating end of life for the fuel channels and Darlington ***fuel channel pressure tubes potentially degrade at a more rapid than anticipated rate***, decisions must be made regarding future plant operation and refurbishment activities. These decisions must be based on data in which there is a high level of confidence.
>
> Currently, Pickering B and Darlington are limited in life by the fuel channel pressure tubes. ***Methodologies and models*** used to demonstrate fitness-for-service, and their technical bases, ***may not be adequate*** to allow continued operation beyond the current nominal operating life at Pickering B (to at least 240k EFPH) or operation to the end of the nominal operational life at Darlington (210k EFPH) or beyond. Mitigating actions which can help justify continued fuel channel fitness-for-service must be identified and incorporated into business planning.
>
> A major hurdle is that the time to reach fitness-for-service limiting conditions, and the exact criteria for this limit, are not well defined. This creates ***technical and regulatory risk*** and uncertainty in operation beyond the nominal operating life for these reactors.
>
> The objective of this project is to provide high confidence projections of the time to reach fitness-for-service limits as they relate to various degradation mechanisms related to fuel channels in Pickering B (to achieve 240k EFPH) and Darlington (to achieve 210k EFPH) reactors.
>
> To achieve this objective, by the end of 2012, predictions of the

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[5] CD# NK30-CORR-00531-06229, *OPG's Initial Response to CNSC Review of Pickering NGS-B Continued Operations Plan-Action Item 2010-8-05 (2461)*, Attachment 1, page 10, G. Jager to M. Santini, April 26, 2012

> impact of the limiting degradation mechanisms must be able to be made with ***a high or very high (>70%) level of confidence***.[6]

7.1. These two documents present a puzzling dichotomy for the Pickering NGS relicensing review. CNSC is requiring assurance of safety for ten years beyond the end of useful life while OPG is simply analyzing the safety of Pickering's fuel channels to the end of their useful life, which it hopes will be 240,000 EFPH. However, these two standards are mutually incompatible.

7.2. Do the people of Toronto deserve assurance of their safety beyond a 70% level of confidence? Because, OPG states that the safety of the fuel channels is only 70% assured and claims that this 70% safety level in the fuel channels is a "high or very high level of confidence". Indeed, this is a very low safety bar indeed. In the university system where I teach, 70% is barely passing and is in fact the minimum acceptable grade to earn in order to receive a diploma.

7.3. Even OPG recognizes the complexity and risk involved with its attempt to extend the operating life of the fuel channels. In the *Fuel Channel Life Management Project*, OPG said,

> It is noted that there is a significant degree of uncertainty in this project, both in the ability to complete some of the tasks identified in the time allotted and in the overall outcome. To accommodate this, risks will be constantly monitored and scope changes identified.[7]

7.4. Further in the document, OPG confirmed Dr. Greening's analysis regarding the lack of expertise of its own staff to perform fuel channel analysis, stating:

> However, the scope of this project is of a fixed duration and the resources required fall far in excess of those available within MCED. In addition, OPG does not have the facilities to conduct the necessary R&D works defined by the project.[8]

8. Allowing Pickering to continue to operate with aging pressure tubes is an

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[6] N-PCH-31100-10000, *Fuel Channel Life Management Project*, Page 1
[7] N-PCH-31100-10000, *Fuel Channel Life Management Project*, Page 3
[8] N-PCH-31100-10000, *Fuel Channel Life Management Project*, Page 4

accommodation that that is in direct opposition to the technical findings and conclusion reached regarding the Darlington nuclear power generating stations where complete refurbishment of the reactor tubes was required as a condition of extending the useful life of those reactors. The population of Toronto deserves the same degree of protection as the populations living near the Darlington nuclear power generating stations.

9. Given the potential risk to the Toronto area and the 4 million people residing there, it is my expert opinion that the ongoing operating uncertainties are significant and do not warrant substantially risking public and safety in order to extend the life of old and outdated reactors like those at the Pickering Nuclear Generating Station. Quite simply, nuclear plants like those at Pickering should not be allowed to operate based upon *mysterious unfounded calculations* or operating confidence levels as low as 70%. While both OPG and CNSC claim that extending the life of the Pickering Nuclear Generating Station is based upon hard data and pure scientific analysis, it appears that there is a considerable amount of *guesswork* underlying each organization's calculations.

OTHER SYSTEMS, STRUCTURES AND COMPONENTS (SSC)

10. A thorough nuclear engineering analysis must look at the whole forest of components, not just a few trees that support a specific political and financial agenda.

    10.1. There seems to be the extensive focus by both OPG and CNSC to analyze and limit fuel channel failures, while totally ignoring the bigger picture that Pickering is an aging and deteriorating plant designed 50-years ago and constructed 40-years ago. Material degradation throughout the plant is an aging management issue similar to those occurring throughout the world in nuclear plants of comparable age and materials, and greatly exacerbated by the inherent complexity of the piping systems in CANDU reactors. But other systems are also degrading.

10.2. In its initial *Response to CNSC Staff Comments Regarding the Pickering NGS-8 Continued Operations Plan*[9], OPG stated that there is a 30% risk that a steam generator will fail during the extended operation of the Pickering units. This shows that even OPG believes that there is a significant risk of component failure (SSC) other than the pressure tubes. Such an accident would challenge safety systems and release considerable radiation to the environment and the surrounding population.

10.3. Even without severe Canadian freeze and thaw cycles to which Canadian plants are subjected, reactors throughout the world that were built in the 1970s are already experiencing detectable levels of concrete degradation as foundations are exposed to freeze and thaw cycles in ground water. For example, in the United States, there are many facilities that are already experiencing significant detectable levels of degradation in the concrete foundation, including Seabrook in New Hampshire, Millstone in Connecticut, and Hope Creek in New Jersey.

10.3.1. Concrete foundation degradation is both insidious and difficult to detect. The majority of this degradation is occurring out of eyesight making inspection and analysis challenging and quite difficult. At New Hampshire's Seabrook Nuclear Power Plant, the strength in some of the concrete has already deteriorated by 25%, and Seabrook was built 15-years later than Pickering. Weakened foundations severely compromise each nuclear power plant's ability to withstand accidents and seismic events.

10.3.2. In my opinion that is based upon the available documentation, both OPG and CSNC are not adequately addressing the concrete foundation degradation issues facing Pickering.

10.4. A second weakness in both OPG and CNSC's analysis of the other systems, structures, and components (SSCs) to withstand design basis events is their

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[9] OPG *Response to CNSC Staff Comments Regarding the Pickering NGS-8 Continued Operations Plan*, April 26, 2012

analysis of underground cables that are also subject to the same harsh environment that the concrete foundations experience. Worldwide experience has shown that the insulation on these 40-year-old wires is likely to breakdown, with catastrophic consequences. Once again, Fairewinds' analysis, based upon the available documentation, shows that both OPG and CNSC have not adequately addressed the condition of the underground wires at Pickering.

10.5. OPG's analysis is not adequately conservative and downplays the likelihood of equipment failures.

10.5.1. The probabilities used in OPG's analysis do not adequately reflect the age-related degradation of the individual components within Pickering.

10.5.2. By not accounting for age-degradation, OPG introduces a favorable bias to its technical safety assessment.

10.5.3. These problems are especially noticeable in reviewing the significant problems with both the reactor components and other SSCs (systems, structures, and components).

10.5.4. More disturbingly, the favorable assumptions applied and submitted by OPG when calculating the Large Release Frequency (LRF) of 8.03E-6 *are extraordinarily near* OPG's LRF safety limit of 1.0E-5[10], and *exceed* OPG's LRF safety goal of 1.0E-6.

11. Fairewinds believes that it is not appropriate to make any determination regarding the possible relicensing of Pickering given that the CNSC says that it does not expect to complete a thorough review of the risk assessment analysis "of all Pickering B PSA reports" until June 30, 2014.[11] Given how dangerously close the Large Release Frequency is to the final CNSC safety goal, and given that CNSC will not complete its analysis for another 14-months, it would be imprudent for this body to allow a 5-

[10] *Public Hearing: Day 2: Information Regarding a License Renewal: Submitted by CNSC Staff*, Page 5, https://docs.google.com/file/d/0B0Xz0yCKpNGrREhlaFo1bDFJMnc/edit

[11] Ibid

year license renewal without adequate public review of the full CNSC analysis.

11.1. In the OPG and CNSC staff licence renewal application, OPG and CNSC staff are proposing:

11.1.1. A five-year renewal for all eight reactors with the Commission *delegating* to staff the authority to approve the continued operation of reactors past 210,000 EFPH once the studies have been completed.

11.1.2. OPG has not provided the necessary studies to back up its safety claims.

11.1.3. Thus the convoluted process the Commission is attempting to establish creates no opportunity for acceptable and admissible independent scientific and public review of OPG's safety claims.

11.2. As a nuclear engineer with more than 40-years of nuclear engineering experience in operations and management up to the position of Senior Vice President, I respectfully request that the Commission deny the OPG application for a five-year licence and provide only a temporary licence while OPG completes the rest of its safety studies for the statutorily required public review by the Commission. I also request that the Commission deny the delegation of authority to its staff since this also does not meet the statutory requirements of the legitmate public review process.

11.3. The relationship between OPG and the Canadian Nuclear Safety Commission is eerily similar to the relationship between the Japanese regulator NISA and the Japanese nuclear power generators prior to the triple meltdown at Fukushima Daiichi. Fairewinds Associates, Inc has written an international report entitled *The Echo Chamber Effect*[12] that describes the extreme risks of operating nuclear power stations when the regulator has been captured by the industry.

[12] *The Echo Chamber: Regulatory Capture and the Fukushima Daiichi Disaster* http://www.fairewinds.com/content/lessons-fukushima

LESSONS LEARNED AT FUKUSHIMA DAIICHI NOT IMPLEMENTED

Since the Fukushima Daiichi accident, Fairewinds has extensively studied the triple meltdown at Fukushima Daiichi. During two lecture tours in Japan I have met with Japanese engineers, concerned citizens, and local and national government officials.

- On August 30, 2012, I was invited to be the Keynote speaker at the Tokyo University Symposium entitled the ***International Symposium on the Truth of the Fukushima Nuclear Accident and the Myth of Nuclear Safety.***
- I was also an invited speaker at a symposium at the New York Academy of Medicine on March 11, 2013 entitled ***Fukushima Two Years Later: Global Symposium to Address Mounting Medical & Ecological Consequences.***
- The Japanese firm Shueisha Publishing has published my analysis of the Fukushima Daiichi accidents. Entitled ***Fukushima Daiichi: The Truth and the Way Forward,*** this scientific analysis of the Fukushima Daiichi accident was listed as the number one science book in Amazon.jp's science section for more than five months in 2012.
- In addition to appearing as an expert on the Fukushima Daiichi accident more than 20 times on CNN in the United States as well as more than 100 separate television, radio, and print interviews in the US, I was also interviewed numerous times by Canadian radio and television, including CBC.
- Due to my nuclear engineering background and in light of my engineering analysis of Fukushima Daiichi accident, I am uniquely qualified to speak about the lessons learned from the Fukushima Daiichi accident and corrective actions that all reactors, including Pickering, must implement in order to be prepared for an accident beyond its design basis.
- After reviewing OPG and CNSC's analysis of lessons learned from the Fukushima Daiichi accident, I conclude that the Canadian response to the accident and proposed improvements are inadequate and incomplete, especially for the Pickering site. The nearness of Toronto to the Pickering site and the emergency

evacuation it might necessitate should, in and of themselves, be reason to deny a license renewal. Simply put, in a serious accident at Pickering, the Ontario government would find it impossible to evacuate Toronto.

12. There are three major mechanical flaws in the Pickering design that have not been addressed in the response to the Fukushima Daiichi catastrophe:

12.1. First, the Fukushima Daiichi accident clearly demonstrates that damage to one unit can adversely affect the remaining units on the site.

12.1.1. The detonation at Fukushima Unit 2 damaged Units 3 and 4 that are adjacent to it.

12.1.2. Pickering has six operating reactors and severe damage to any one of them could cause damage to adjacent units.

12.1.3. Such an accident could cause a single reactor accident to spiral out of control.

12.1.4. Like dominos, adjacent Pickering units could become involved in an ever-worsening series of accidents.

12.1.5. Rather than addressing this possibility, OPG and CNSC appear to be ignoring it, thereby risking public health and safety for one of the most densely populated areas of Canada.

12.1.6. The single Vacuum Building at Pickering is designed to accommodate a single accident -- not the cascading series of events that Fukushima Daiichi proved is distinctly possible at multi-reactor generating sites.

12.2. Second, at the Pickering nuclear generating station multi-reactor site, the evidence reviewed shows that in the event of a design basis accident that disables two reactors, the Vacuum Building would not be able to perform its safety functions for both.

12.2.1. Because the design of the Pickering units can only accommodate one Vacuum Building, it is impossible to cope adequately with significant damage from cascading multiple accidents.

12.2.2. Furthermore, rather than admit these multi-reactor site flaws and take steps to protect public health and safety, OPG and CNSC are currently ignoring these significant safety risks.

12.3. The third issue facing the Pickering units is a LoUHS (Loss of the Ultimate Heat Sink). Television footage has led people around the world to believe that Japan's March 10, 2011 tsunami and earthquake and their destruction of the diesel generators caused the cascading destruction of the Fukushima Daiichi units that began on March 11, 2011. Such an assessment is inaccurate and incomplete because the tsunami's destruction of the diesel generators was not the cause of the multi-unit destruction.

12.4. Instead, the destruction of the emergency cooling pumps that pump cooling water into the diesels in order to keep them cool is the reason for the cascading failures at the Fukushima Daiichi multi-unit site. The accident that occurred is a design basis accident that is called the Loss of the Ultimate Heat Sink (LoUHS).

12.4.1. Design basis accidents are accidents for which the nuclear industry prepares with redundant safety features so that if a natural disaster or reactor event causes one safety system to fail, then the nuclear plant has a back-up system in place.

12.4.2. At Daiichi, all the operating and back-up systems failed and did not perform as designed. Even if the diesels had survived the tsunami, they would have failed in a short time because they could not be cooled.

12.4.3. Of course a 15-meter tsunami will not hit the Pickering Units, but the issue is not one of whether or not a tsunami or major flood could compromise the reactors. Instead the issue revolves around the fact that critical safety systems failed – for whatever initiating reason -- and did not operate as designed.

12.4.4. There are many conditions under which the Pickering nuclear stations would be vulnerable to a LoUHS design-basis accident. By not analyzing the lessons learned at Daiichi and by not implementing the appropriate design and engineering modifications necessary to compensate for such events, OPG and CNSC have not learned the most important lessons from the devastating Fukushima Daiichi catastrophe. There are plausible scenarios during which a LoUHS (Loss of the Ultimate Heat Sink) scenario might occur at the Pickering site, especially given the units positive reactivity coefficient.

12.5. As I have detailed earlier in this report, the operating Pickering reactors have significantly *less* redundancy than the Fukushima reactors that each had a separate containment system. Pickering, however, shares one containment among six separate reactors. The weakness of this lack of redundancy is detailed in OPG's own risk assessment[13] that shows that the core damage frequency for the Pickering B reactors is basically the same as LRF. Otherwise put, there is a significant lack of defence in depth.

13. Submitted by CNSC Staff, the document: *Public Hearing: Day 2: Information Regarding a License Renewal*, contains a long list of post Fukushima Daiichi action items to be implemented at the Pickering and other nuclear power generating station sites.

13.1. For example, the CNSC staff stressed that it intends to:

> Assess the adequacy of the existing means to protect the containment integrity and prevent uncontrolled release in beyond design basis accidents including severe accidents.[14]

13.2. While this is a noble goal that is imperative to protect public health and safety in the heavily populated Toronto area, the action item due date has been postponed until 2015, only three years before the Pickering station units are scheduled to be permanently shutdown if their license is not renewed.

13.3. Similarly, according to Action Item 1.4.1 of the CNSC post Fukushima Daiichi

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[13] *Pickering Risk Assessment*, Page 102, http://www.opg.com/power/nuclear/pickering/NK30-REP-03611-00021.pdf

[14] *Public Hearing: Day 2: Information Regarding a License Renewal, Appendix A-3*: *Fukushima Action Items* Page 30, Item 1.3.1. https://docs.google.com/file/d/0B0Xz0yCKpNGrREhlaFo1bDFJMnc/edit

list states that OPG will develop:

> A plan and schedule for design enhancements to control long-term radiological releases and, to the extent practicable, unfiltered releases.[15]

13.4. However the report notes that the plan will also not be completed until 2015, which then makes it too late to design, fabricate and implement any crucial safety features and requirements prior to the presently scheduled permanent shutdown of the Pickering Units. In other words by allowing OPG to have such an extension on just the plan and schedule for this essential safety parameter, it is clear that no new safety features can or will be put in place.

<u>RELICENSING AGING NUCLEAR GENERATING STATIONS</u>

14. Gentilly-2, Quebec's only operating nuclear power plant was taken off the grid December 28, 2012 following a decision by the new provincial government immediately after the September 2012 elections.

14.1. During the past four years, the 29-year old 635 MW heavy-water reactor operated with an average load factor of only 64% and was slated for major upgrading. Following significant cost overruns for the refurbishment of the Point Lepreau plant the costs for the complete renovation of Gentilly-2 were reassessed. When the refurbishment costs were estimated to have increased to CAD4.3 billion and the plant showed marked deteriorated conditions, operator Hydro-Quebec "recommended the closure of the plant to the Quebec government"[16].

14.2. Deteriorating and aging nuclear generating stations is a significant issue at plants throughout the world. When the Pickering NGS was designed and built, the slide rule, the old mechanical analog computer, was used to make the

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[15] *Public Hearing: Day 2: Information Regarding a License Renewal, Appendix A-3*: *Fukushima Action Items* Page 30, Item 1.4.1. https://docs.google.com/file/d/0B0Xz0yCKpNGrREhlaFo1bDFJMnc/edit

[16] http://nouvelles.hydroquebec.com/fr/communiques-de-presse/185/hydro-quebec-confirme-la-fermeture-de-la-centrale-de-gentilly-2-a-la-fin-2012/?fromSearch=1#.UN7AObbiSs8

calculations.

14.3. The design life of these older nuclear units was based upon the maximum lifetime expectancy for critical components like nuclear grade concrete, tubes, piping and components. At Pickering, for example, it is not technically possible to ascertain the condition of the kilometers of tubes and piping that wend their way through each unit.

14.4. Until very recently Thierry Vandal was the CEO of Hydro Quebec. When former CEO Vandal testified to the Parliamentary Commission hearings in Quebec City in January regarding the aftermath of the shutdown of the Gentilly-2 reactor, he said,

> I would no more operate Gentilly-2 beyond 210,000 hours than I would climb onto an airplane that does not have its permits and that does not meet the standards. So, it is out of question to put anyone, i.e. us, the workers, the public, and the company, in a situation of risk in the nuclear realm.[17]

14.5. The industry term is called "aging management", and the nuclear power industry is facing significant engineering and fabrication challenges as well as substantial and unanticipated refurbishment and repair expenses. I have testified to the US Nuclear Regulatory Commission and its boards, state legislatures, and to regional regulatory commissions regarding the numerous *aging management issues* confronting today's nuclear power station generators. Thierry Vandal's comments relating to Gentilly-2 could be directed to many of the aging nuclear generating stations in Canada, the US, Japan, France, and other nuclear power locations around the world.

[17] HQ President Thierry Vandal's testimony in the Commission Parlementaire held 29-30 January 2013 in our Parliament in Québec City. Translation by Michel Duguay, Nuclear Physicist and Professor of Electrical Engineering at Laval University.

CONCLUSION

In conclusion and in my expert opinion, the license extension beyond the original design life of the Pickering station to 2018 should be denied. If an accident were to occur at Pickering, the plant is unprepared to prevent the release of significant quantities of radioactive materials. Radioactive materials released from nuclear power accidents contaminate the air, the water and the soil, and enter into the water table and food chain. The environmental and health damage created by the release of radioactive materials lasts for decades after any radioactive material release has occurred.

OPG has yet to produce the safety studies required to support its claims that the station's limiting components can operate reliably and safelty for the next five years, which is past their design life. It would therefore be imprudent for the Commission to approve such a renewal without all the statutorily required technical and safety information.

With six operating nuclear reactors, the Pickering Station is one of the largest nuclear power plants in the world. It is also one of the oldest nuclear power plants and one of the closest nuclear stations to a major population center. These three factors pose a unique risk that would not be deemed acceptible in the United States.

Given the Pickering Station's already surprisingly high large release frequency, it is imperative to improve emergency preparedness in Toronto and its surrounding area.

The evidence reviewed by Fairewinds Associates makes it clear that both the CNSC and OPG have failed to grasp the magnitude of the essential messages from the Fukushima Daiichi accident. A severe accident could occur at an aging end of design life plant like the Pickering Nuclear Generating Station.

End

Dated the 29th day of April 2013
Arnold Gundersen, MENE
Chief Engineer, Fairewinds Associates, Inc