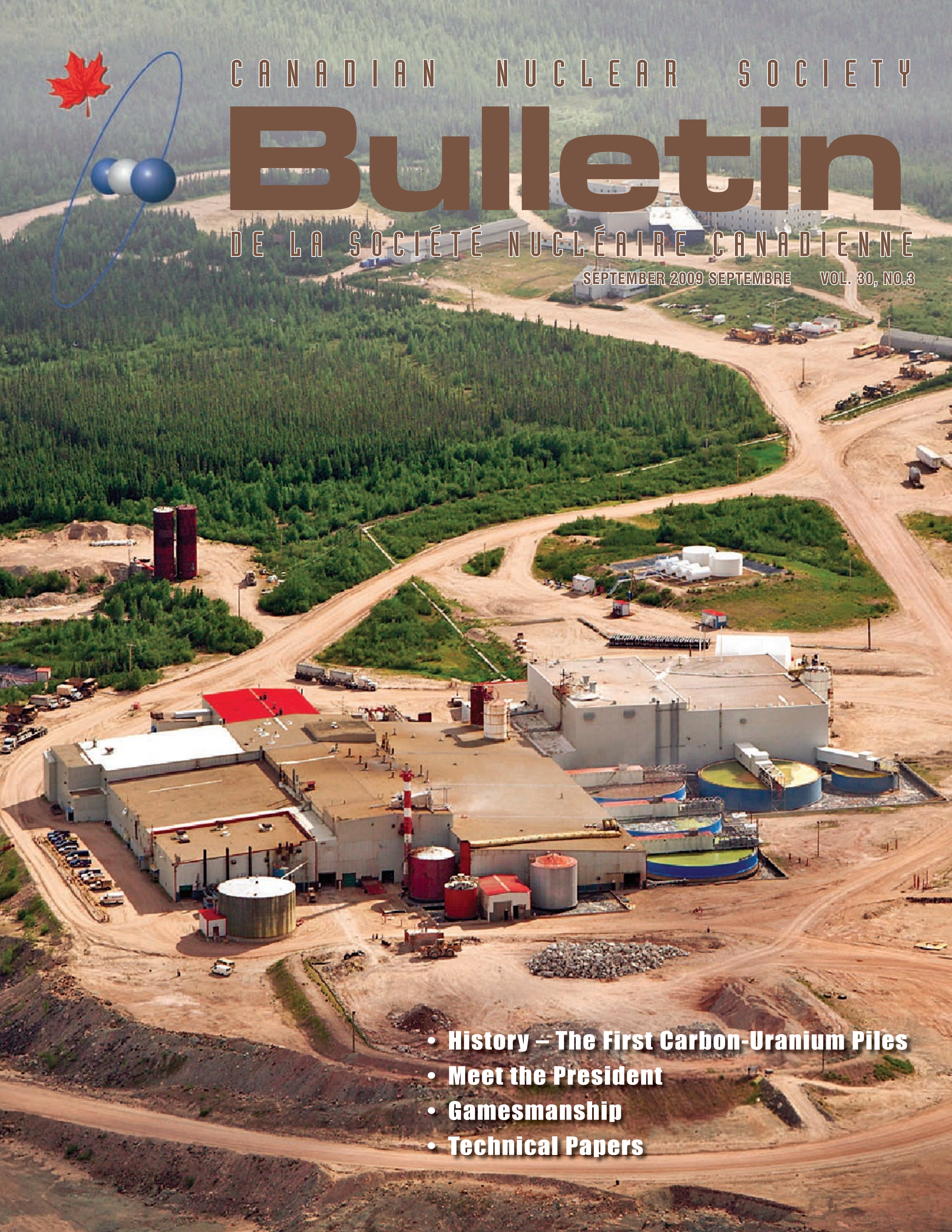
CANADIAN NUCLEAR SOCIETY

# Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

SEPTEMBER 2009 SEPTEMBRE VOL. 30, NO.3



- History – The First Carbon-Uranium Piles
- Meet the President
- Gamesmanship
- Technical Papers

SNC·LAVALIN Nuclear

**Leaders in Design Engineering, Procurement and Construction Management**

# POWER FOR THE FUTURE

Bruce A Generating Station

SNC-Lavalin Nuclear is Canada's largest private sector nuclear engineering organization, providing a complete range of services to the nuclear industry in Canada and internationally, meeting recognized national and international technical and quality standards since 1967. SLN's engineering expertise includes both CANDU and Pressurized Water Reactor (PWR) technology. As part of Team CANDU, SNC-Lavalin has worked on 7 new nuclear units in the past 11 years.

**SNC-Lavalin Nuclear Inc.**

2275 Upper Middle Road East,
Oakville, Ontario, Canada, L6H 0C3
Tel: 905-829-8808 Fax: 905-829-8809
www.slnuclear.com

email: info@slnuclear.com

## EXPERT COUNSEL AND SERVICES

- New Build Nuclear Facilities EPC
- Steam Generator Replacement EPC
- Detailed Design Engineering
- Project, Procurement & Construction Management
- Metrology
- Refurbishment, Station Performance & Life Extension Services
- Operating Plant Support
- Radioactive Materials & Waste Management Services
- Decommissioning Services

# The Price is Right

The Ontario Government decided some time ago that new nuclear build is needed to meet future electricity demand but did not take the traditional course of previous governments in choosing a "Home Grown" technology. Instead it issued a request for proposal (RFP) that began the bid process. Westinghouse, General Electric (which later dropped out) and Areva were now candidates in competition with AECL. Recently, however, Infrastructure Ontario announced that AECL was the only compliant bidder, was the best bid, and then suspended the bid ostensibly because "the price was too high".

Some price information was apparently "leaked" and the Toronto Star reported that the price tag for two ACR-1000 reactors was $26 billion. Infrastructure Ontario denied that the leak was from their office, although there was never an investigation as to where the leak occurred or indeed if there ever was a leak. Nevertheless, the price has made world news and many people around the world are wondering how Ontario made such a big mess of the bid process.

Let's assume the $26 billion is correct (the Premier has neither denied nor confirmed the numbers in the Toronto Star). Since the RFP required price certainty, and since AECL was the only compliant bidder, this may be why the price is higher than what the province expected - any bidder would include a risk contingency to mitigate unforeseen cost escalation such as rising prices for building materials or design changes mandated by the regulator. But is $26 billion too much to pay? Numbers are not always as they seem.

The $26 billion is all in – it includes construction of two reactors, turbines and auxiliaries, transmission and distribution, infrastructure (including roads for construction), 60 years of fuel and decommissioning. Averaged over 60 years, this works out to less than $0.5 billion per year. (I'm not a finance whiz but this looks about right). It sounds like a lot, but putting it into perspective, the LCBO (for example) pays a dividend to the province of $1.4 billion per year. Two ACR-1000 reactors deliver about 2200 MW to the grid, and using 2008 sale prices for OPG regulated nuclear ($53/MWh), they would generate revenues of nearly $1 billion per year (assuming 90% capacity).

Of course it is wishful thinking to assume electricity prices would remain constant over 60 years, but I think you see my point.

Although the Infrastructure Ontario denies the leak and will not confirm the price tag, they have recently confirmed that Lifetime Unit Electricity Cost (LUEC), which is the cents per kWh rate, was the main basis in their assessment, not the capital cost. There has been no release of this information, known only by Infrastructure Ontario and the vendors, who are under a "gag" order.

The Ontario government says $26 billion is too much, but I don't buy it. It defies logic. In my opinion the price is right. If the price is reasonable, why did the government suspend the bid? We will never know because this Government, elected on a platform of openness, chooses to keep everything a secret.

When politicians sense rough waters ahead they will find any scapegoat to avoid rocking the boat, and avoiding the inevitable public "greenwash" attacks by suspending the bid while complaining about the price is an effective delay strategy aimed at protecting their parliamentary seats (so to speak). Is this the untold reason for suspending the nuclear decision?

# In This Issue

We are honoured once again to present an item of our heritage thanks to James Arsenault who documents the work by George Laurence developing Canada's first Carbon Uranium Piles. (We intended to run this article in the last issue, but were forced to drop it due to the unexpectedly long W.B. Lewis Lecture given at the Annual Conference in Calgary. However, history is history and will keep forever!).

There were no CNS Conferences to report on for this issue so we have included three technical papers that were presented in Calgary. There is also an extended General News section due to the many announcements and recent achievements in the nuclear industry.

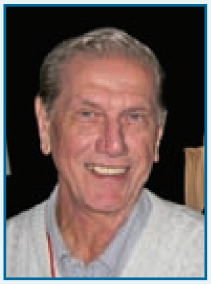
In CNS News we report on the passing of the President's Gavel to Eleodor (Dorin) Nichita. He is "profiled" under the title "Meet the President".

Also in CNS News is a request from the Canadian Standards Association (CSA) for technical experts in various fields of the nuclear industry. There has been discussion as to whether the CNS, as an organization, should participate in the CSA program, but it was decided that the expertise lies not with the CNS, but with the individual members themselves. As such, some support from a member's employer would be expected and this is being encouraged.

And last but by no means least, Jeremy Whitlock, our eminent communicator, looks at our nation at cloud level and sees some stormy weather ahead followed by a few sunny breaks.

Your contributions, letters, comments and suggestions are always welcome!

Cheers!



Some random thoughts on the state of the Society and the Canadian nuclear scene.

## The Society

Planning is well under way for the 2010 CNS Annual Conference, which will be held in Montreal May 24 – 27, a week or more earlier than usual because of the popularity of that bilingual city. Under the chairmanship of Adriaan Buijs, the organizing committee (all volunteers) has already met three times and will have met again before you see this. If you are interested in helping contact Adriaan. (The "meetings" are all by teleconferencing.)

As well as being earlier than usual, the conference will also differ by starting on a Monday instead of the usual Sunday, primarily because the Monday is May 24, Victoria Day.

An important component of the annual conferences has been the Honours and Awards ceremony, which, for 2010, is tentatively proposed to be held at the lunch on the first full day. It has become increasingly difficult over the past few years to obtain nominations. When you read this give some thought to colleagues or others of whom you are aware who deserve to receive the recognition of their peers for their contribution(s) to the Canadian nuclear program. Then contact Doug Hink or Krish Krishnan, the co-chairs of the Honours and Awards Committee.

The Society is also easing into the public communication arena. One endeavour will be an information evening at UOIT in Oshawa on October 15. It is being held in conjunction with National Science and Technology Week. Our eminent communicator, Jeremy Whitlock, will present his excellent talk, "Splitting Atoms, Canadian Style", on 100 years of Canadian nuclear science and application, and our "dean of deans", Dan Meneley, will give his presentation "Turning Rocks into Gold – Electric Gold" covering nuclear power from uranium mines to spent fuel.

In addition, the president has encouraged the drafting of possible public statements on issues such as the need for a replacement of NRU and the relative methods of producing radioisotopes for medical purposes.

## The Canadian nuclear scene

The repeated postponements of a decision by the Ontario government on new nuclear power units has cast a pall over much of the nuclear community.

Economic circumstances have certainly aided the typical political inclination to procrastinate. As is generally accepted, and very evident with the current Ontario government, politicians cannot see beyond the next election. Unfortunately major projects such as the proposed nuclear units require a very long-term viewpoint.

The situation is a marked contrast to that of the 1950s when the leaders of the then Ontario Hydro recognized that the province was running out of available hydro-electric sites and turned to the new but promising source of nuclear power. Ontario Hydro was an integrated organization involved in the entire electricity scene, from generation through to distribution. Further it was able to issue bonds to cover major construction projects giving it the ability to think of the long-term needs of the province. All of the existing Ontario units resulted from those far-sighted decisions.

In 1999 the provincial government of Mike Harris broke Ontario Hydro apart and created five entities to do the tasks it had done, very successfully, for eight decades. Sadly, augmenting the political philosophy of the Harris government, the management of Ontario Hydro had become unfocussed. That led to importing a group of reputed experts from the USA who quickly declared the utility dysfunctional and shutdown six units.

It is very unlikely that a single power organization will ever be recreated in Ontario but the long-term planning of generation and distribution needs to be isolated from the pressures and whims of the political party in power. Unfortunately, that seems less likely every day with none of the leaders of the organizations supposedly planning the electricity system showing any independence.

While dithering about nuclear plants the province is pushing ahead with wind units, paying two and half times that paid to the nuclear generators, and augmenting them with gas-fired units burning a precious commodity.

Adding to the political whims of the Ontario government is the indecisiveness of the federal government in its role as owner of Atomic Energy of Canada Limited. The nominally responsible minister, Lisa Raitt of Natural Resources Canada, even publicly speaks about splitting the company in two, ostensibly to make it easier to sell. The federal government's apparent refusal to accept some of the financial risk of a first of a kind station has provided ammunition for the provincial postponement of its decision.

It is amazing that our country has survived such "leadership".

*Fred Boyd*

## Contents



~ Cover Photo ~

Rabbit Lake – located in northern Saskatchewan, Rabbit Lake is the longest producing uranium operation in Saskatchewan.

*– Photograph courtesy of Cameco Corp.*


CANADIAN NUCLEAR SOCIETY

# bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

**ISSN 0714-7074**

The *Bulletin of the Canadian Nuclear Society* is published four times a year by:



The Canadian Nuclear Society
480 University Avenue, Suite 200
Toronto, Ontario, Canada, M5G 1V2
Telephone (416) 977-7620
Fax (416) 977-8131
e-mail: cns-snc@on.aibn.com


Le Bulletin SNC *est l'organe d'information de la Société Nucléaire Canadienne.*

CNS provides Canadians interested in nuclear energy with a forum for technical discussion. For membership information, contact the CNS office, a member of the Council, or local branch executive. Membership fee for new members is $97.85 annually, $58.71 for retirees, free to qualified students.

*La SNC procure aux Canadiens intéressés à l'énergie nucléaire un forum où ilf peuvent participer à des discussions de nature technique. Pour tous renseignements concerant les inscriptions, veuillez bein entrer en contact avec le bureau de la SNC, les membres du Counseil ou les responsables locaux. Les frais annuels d'adhésion pour nouveaux membres sont 97.85$, 58.71$ pour les retraites, et sans frais pour les étudiants.*


**Editor / Rédacteur**
Ric Fluke Tel. (416) 592-4110
e-mail: richard.fluke@amec.com

**Publisher**
Fred Boyd Tel./Fax (613) 592-2256
e-mail: fboyd@sympatico.ca


The comments and opinions in the CNS Bulletin are those of the authors or of the editor and not necessarily those of the Canadian Nuclear Society. Unsigned articles can be attributed to the editor.




Printed by The Vincent Press Ltd., Peterborough, ON

**Canada Post Publication Agreement #1722751**

# Gamesmanship: Will there be a winner or will we all lose?

by Neil Alexander, President of OCI

Much has happened since the last bulletin. Not least of which the countrymen of my place of origin have been watching Wimbledon. As usual there was no English player anywhere near the top position although, in a strategy clearly stolen from the Maple Leafs, there was sufficient promising action early in the tournament to make sure that they tune in next year.

I was following a much more important game of tennis being played out in Ontario. It is a critical game for the nuclear industry and a frustrating one for many of us as, although it affects us a great deal, we are not being allowed to play and our commentary is not being heard.

The game probably started some time ago but the first serve in the final set was served by the Province of Ontario when it powered the ball down to AECL in the form of an RFP for the provision of new nuclear capacity at Darlington. To make sure that AECL took their serve seriously they called in a few of AECL's competitors and made it clear that they might play ball with them instead.

It appears that the AECL return was a good one because they submitted the only compliant bid and, by the Province's own admission, the best bid. (Well done AECL a tremendous response!) The ball that AECL returned did not hit the net, it was not wide, they did not hit it twice, unquestionably the ball was firmly back into the Province's court and so far as I can tell there was no reason why the Province should not have played it.

Instead the Province suspended the process.

It was at this point that McGuinty declared that the ball was in the Federal Government's court and I realized that people really did think this was a game.

Now we can all spend a lot of time debating whether or not a suspended ball has actually been returned or not. I would say it has not. McGuinty clearly believes that it has. But the debate is a moot one. It matters not one jot where the ball presently lies nor indeed who decides to play it next because procurement's are not a game in the first place.

In a game there are winners and losers but while this combat continues all we have our losers. The Canadian nuclear industry loses, Ontario loses and Canada loses. Meanwhile the best McGuinty and Harper can hope for is to make history see the other as the Nuclear Industry's Diefenbaker. Not a great achievement. Likely history will blame them both anyway.

So is there another way?

Yes there is but first all the parties need to understand that while the selection of the supplier is a competitive process that competition is between the vendors not the vendor and the buyer. At no point should the buyer and vendor be in combat. Successful negotiations should not produce winners and losers and they do not come from a ball being thumped backwards and forwards across a barrier. Successful procurements produce only winners and they are achieved through breaking down barriers not building them up.

My advice to McGuinty and Harper is that if they don't want to risk a very long lasting and very negative legacy as the new Diefenbaker they should:

1) End the game playing
2) Develop an inclusive approach to conducting the negotiations
3) Seek to find a way to build reactors in Ontario at an appropriate price and potentially put Canadian reactor technology back in the world stage.

Working together they can both win! And that is what procurement is all about.

Let us hope that they stop hunting for the ball and go and have a chat over the net before darkness falls and everyone gives up and goes home.

## What's Wrong with Ontario's CANDUs?

We cannot wait for the ACR-1000 to prevent the degradation of Ontario's power grid. The existing CANDU fleet has to provide more operational flexibility.

The Ontario grid is suffering through unprecedented periods of surplus baseload generation (SBG), even during the summer months, which requires flexible generation that can be quickly moved up and down. Our CANDU units were not designed to respond to frequent load following dispatches but they should be able to load cycle, with fast reactor power changes available down to 60 percent of full power with a slower return to full power, This was done successfully in the 1980s and is explained in "Nuclear and Wind on the Ontario Electricity Grid" published in the June 2009 edition of the CNS Bulletin (Vol. 30, No.2).

Although Bruce B has responded to many manoeuvring requests from the Independent Electricity System Operator (IESO) during SBG periods it has had to do so by using the steam bypass system while keeping the reactor at, or near, the licensed output. This requires a lot of preparation and has put a lot of wear and tear on a system not designed for frequent use like this. Bruce Power has told the IESO that SBG is its "number one operational concern" and that "manoeuvring nuclear units represents a significant reliability risk to the province". Because of this concern one of its units was shutdown for three weeks in August.

On 2009 June 30 Ontario Power Generation (OPG) told the IESO that it too has manoeuvring concerns. "OPG's nuclear units must accomplish all manoeuvring for SBG management through reactor power changes. During reactor power changes the reactor's chemistry and physics limits must be respected. Respecting these limitations imposes certain time constraints on output changes. For example, one class of reactor may make an initial manoeuvre that must be followed by a multi-hour hold in output prior to either increasing power or any further reductions. The specifics of other restraints on manoeuvring capabilities are too detailed to provide in this document".

So, it appears that OPG units can change output only by changing reactor power, and can do so only in small steps, while Bruce B takes a deep output reduction rather than respond to multiple smaller reductions to avoid increasing the risk of a forced outage. This is not flexible operation. Clearly there are questions that need to be answered, and hopefully experts from Bruce Power, OPG and AECL can provide the answers to the following:

(1) Why aren't power changes being carried out the way they were designed to be?
(2) Will improvement to manoeuvring capability, rather than power rating increases, be the goal from using the new CANFLEX fuel with its increased operating and safety margins?
(3) With more nuclear manoeuvring will Darlington's three-year outage plan still be feasible?
(4) Since Bruce A does not have adjusters will there be an upgrade of the steam bypass system of units 3 and 4 to enable them to reliably contribute to some load cycling?
(5) Will Bruce and Darlington refurbishment allow units to meet their load cycling design intent?
(6) Will refurbishment of Bruce B allow more operational flexibility during periods of SBG load cycling by allowing reactor power changes rather than the current practice of using steam bypass?
(7) Will the Bruce B and Darlington refurbishments also include upgrades to the steam bypass system to improve the response of the units to more frequent load cycling dispatches?
(8) Will the ACR-1000 and the EC6 also suffer from "certain time constraints on output changes" similar to those of OPG?

At present, the dispatch order for the different generators on the grid allow for nuclear units to be dispatched down before non-dispatchable wind and baseload hydro. This needs to be changed. Depending on circumstances our critical nuclear units should be the last units to be manoeuvred, after wind and must-run hydro. This would reduce the frequency of current nuclear manoeuvres and the risk of forced outages.

On 2009 July 23 Bruce Power announced that it was cancelling its application for new build in Ontario and will focus instead on refurbishing its units 3 to 8. Together with the delay in new nuclear at Darlington it means the introduction of a significant amount of more flexible nuclear generation into the Ontario electricity supply is put off indefinitely.

Presently the grid is balanced during SBG periods by shutting down or load cycling nuclear units, albeit inefficiently and with difficulty, and allowing more flexible hydro, (when available), and gas-fired units to load follow. Since more periods of SBG are expected we have to improve the load cycling capability of Ontario's current nuclear fleet as much as possible during the refurbishments to prevent degradation of the power grid. Load following will have to wait for the ACR-1000.

Don Jones
Mississauga, Ontario

# George C. Laurence and the First Carbon-Uranium Piles

by James E. Arsenault, P.Eng.

*"This investigation was carried out to test the probability of obtaining a sustained chain reaction in a large heterogeneous system of carbon and uranium oxide, $U_3O_8$."* (Laurence and Sargent, 1941-1942).

## 1. Introduction

In the spring of 1940, while working at the National Research Council (NRC) in Ottawa, George Laurence conceived independently a design for a subcritical, chain-reacting pile of carbon and uranium. Starting in March, experiments were undertaken and by September the first pile was constructed (Laurence, 1947).

Three piles were built. The first two gave inconclusive results but the third configuration, which is the pile described here, provided a satisfactory set of measurements when the uranium oxide density was doubled. The results showed clear evidence of nuclear fission and detailed analysis indicated that the full-size pile would not have been critical, i.e., self-sustaining, unless materials of greater purity were used.

This line of research concluded in December 1942 when Enrico Fermi achieved the first critical graphite-uranium pile at the University of Chicago. Originally Laurence was well ahead of Fermi but with the U.S. entry into World War II atomic research accelerated in that country, giving Fermi practically unlimited resources. In contrast, Laurence was fully engaged in other war work and carried on his nuclear research on a part-time basis. Nevertheless, this pile was a remarkable experiment in Canadian scientific history.

## 2. George Laurence (1905-1930)

**Figure 1:** G. C. Laurence. *NRC Archives*

George Craig Laurence was born in Charlottetown, P.E.I., in 1905 (Carmichael, 1989) while Ernest Rutherford was still at McGill establishing the foundations of nuclear science with his ground-breaking 1904 book *Radioactivity*. Rutherford moved on to the University of Manchester in 1907 and finally to the Cavendish Laboratory at Cambridge University in 1919, where he remained for the rest of his life. There he was largely responsible for training two generations of nuclear scientists. One of these was George Henderson, who began teaching in the Physics department at Dalhousie University in Halifax in 1924.

In 1921 Laurence entered Dalhousie in the Arts program but switched to Science in his junior year and also began to study German in order to follow the great scientific strides being made in Germany at the time (Laurence, 1975-1976). He earned a B.Sc. in 1925 and was set a problem by Henderson involving the measurement of the range of alpha particles in air, for which he earned an M.Sc. in 1927. (This work was noted in 1930 by Rutherford in his book *Radiations from Radioactive Substances*.) In the same year Laurence won an 1851 Exhibition Scholarship, intended for students coming from the Commonwealth, for two years of study at the Cavendish Laboratory under Rutherford.

The Cavendish Laboratory that Laurence entered was the leading centre for nuclear research in the world and he crossed paths with many who were later destined to become well known leaders in the field. His Ph.D. research involved the measurement of the velocities of alpha particles from several different radioactive emitters. At the time there were a few Canadians in attendance, several of whom became prominent in nuclear research in Canada. In particular, B.W. Sargent began his studies at the Cavendish in 1928. He later collaborated with Laurence in performing the complex pile calculations.

Graduate student expenses at the Cavendish were a source of controversy. Laurence participated in a survey and decided that expenses were unnecessarily high due to regulations established by classics and literary men (Cathcart, 2004). This situation is an indication of where scientific research students then fit in the scheme of things at the university.

In Canada, the NRC was expanding and it advertised for staff in *Nature*, which Rutherford brought to the attention of Laurence. He applied and was hired in 1930. His Ph.D. degree followed in 1931. At this stage Laurence was trained in nuclear science at the highest level and was aware also of the published progress being made in the field at other laboratories around the world. Over the next 10 years progress was spectacular. Figure 1 shows an early photograph of Laurence, taken while working at the NRC.

## 3. Progress in nuclear science (1930-1940)

In February 1932, after several weeks of intense work, James Chadwick at the Cavendish Laboratory confirmed the existence of the long-postulated particle with a neutral charge (Rutherford's Bakerian lecture, 1920) and provided a more complete working model of the atom.

In April 1932, John Crockcroft and Ernest Walton observed the disintegration of the atom at the Cavendish by aiming accelerated protons at a lithium target, resulting in the production of two helium atoms and some energy. The press of the day referred to this as "splitting of the atom".

In January 1934, Frederic and Irene Joliet-Curie, working at Marie Curie's Radium Institute in Paris, discovered artificial radioactivity by bombarding aluminum with alpha particles. In the process aluminum was transformed into heavier radioactive phosphorous which then decayed into stable silicon.

Putting two and two together, beginning in 1934 and for some time thereafter, Enrico Fermi at the University of Rome conducted a systematic program of bombarding all of the known elements with neutrons in increasing order of atomic weight. Not much happened until, beginning with fluorine, he observed the production of heavier radioactive products. Fermi also discovered that he could produce a much stronger response if the neutrons were slowed or moderated. When he arrived at uranium, the heaviest of the then known elements, he believed that he had created transuranic elements, i.e., heavier than uranium, but there was no direct proof of this.

Following Fermi's lead, Irene Joliet-Curie began similar experiments in 1935 and by 1937 had published results that became a source of disagreement with similar experiments at the Kaiser-Wilhelm Institute of Chemistry in Berlin, with respect to the resulting products deduced by radiochemistry.

The team at the Kaiser-Wilhelm, led by Otto Hahn (who had worked with Rutherford at McGill) and supported by Fritz Strassman and Lise Meitner, decided to repeat the controversial French experiment and in early January 1939 arrived at the curious conclusion that it had inexplicably resulted in the production of radioactive barium. Gradually the truth dawned and finally, in February 1939, Lise Meitner and her nephew Otto Frish announced the uranium atom had been split, accompanied by the release of considerable energy.

This news spread rapidly in the physics community and the idea that a chain reaction could produce unlimited amounts of energy soon took hold. All that was required was a self-sustaining supply of neutrons.

In April 1939, the Frederic Joliet-Curie team working at the College de France, which now included Hans von Halban and Lew Kowarski, reported a value of 3.5 +/- 0.7 neutrons per fission; the modern value is 2.3 (Wiles, 2002). With this result physicists around the world could see plainly that the energy stored in the atom was at last practically available but no one knew how to obtain it efficiently.

Further research by Niels Bohr and John Wheeler in September 1939 indicated that it was the isotope U-235 (1/140 natural uranium content) that was almost entirely responsible for fission and neutron production.

Note: The above material was compiled largely from Dahl, 1999; Weart, 1979; and Brown, 1997.

All of this knowledge was freely available in the scientific literature of the time, especially in *Nature* and *Physical Review,* and in the popular press, particularly in the articles of William Lawrence in the *New York Times* and the *Saturday Evening Post*. It was made perfectly clear that nuclear energy would soon be available for peaceful and destructive purposes. Scientific publication continued even after the war began in September 1939 and it was not until 1942 that the publication of nuclear science research ceased completely. It did not resume until after the war and then only on a limited basis, as the work remained classified for many years thereafter.

## 4. GCL (1930-1940)

Laurence began work in September 1930 when the NRC was transitioning from sponsored research in universities to research in its own laboratories. The laboratories were being set up in the recently purchased and no longer existing Edwards Mill buildings on John Street, between Sussex Drive and the Ottawa River. Later as part of the expansion, the NRC built the large and architecturally beautiful stone building on Sussex Drive (see Figure 2), to provide scientists with modern laboratories. It opened in 1932 and remains in use today.

Laurence was appointed Head of the Radium and X-ray Section, which had interests closely aligned with nuclear science but which was not considered to be a legitimate activity (Sargent, 1979). The priorities of the NRC were that of standardization along the lines of the U.S. Bureau of Standards. The standardization for certification of radium sources extracted from the rich pitchblende ore from the Eldorado Gold Mines Limited mine at Great Bear Lake became a continuous service of the Section. In 1936 a nuclear-physical investigation of the radium became necessary when the claim was made (and disproved by Laurence) that the Canadian radium contained significant amounts of a uranium isotope (Mesothorium 1, discovered by Hahn), which would represent a mixed gamma source for cancer therapy and, therefore, would deteriorate rapidly. In November 1936, Eldorado's President Gilbert Labine recognized the assistance provided by the NRC with a plaque presented at a ceremony at the Chateau Laurier in Ottawa. This silver plaque can be seen still near the entrance to the NRC building on Sussex Drive. In 1938 Laurence introduced radiographic inspection procedures for industrial castings. The

**Figure 2:** NRC Sussex Drive Laboratories (1950). *NRC Archives*

standardization activity led to the publication of *The Measurement of Dose in Roentgen Therapy*, co-authored by Laurence and adopted by the Radiological Society of North America in 1939.

When the war started Laurence concentrated on radiographic inspection applications for war material for ships, aircraft and vehicles, and he had little time for research. Nevertheless, he kept up with the advances in nuclear research through the literature and in that sense he was aware of the possibilities with respect to energy release from uranium chain reactions. He also knew through his work with Eldorado that Canada possessed large deposits of uranium and had developed the means to extract it. By spring 1940 he had conceived of a small subcritical graphite and uranium experimental pile and went about assembling the resources to construct it.

At the time the concept of critical mass was understood in scientific circles and preliminary calculations had already shown that many tons of uranium would be necessary if a sphere of natural uranium were to support a self-sustaining chain reaction. The idea was to imagine a sphere with a neutron source in the middle with the sphere getting bigger and bigger, resulting in the multiplication of neutrons until the multiplication became infinite and that was the critical size (Serber, 1988). As the required quantity of uranium was not readily available, experiments were carried out on subcritical piles and the measurements were extrapolated to determine the critical size of a particular pile configuration. To promote the more efficient generation of thermal neutrons, the uranium was formed into small spheres and a moderator was used between them to slow down the otherwise fast neutrons. This was the basis on which Laurence designed, built and measured his piles.

## 5. The Pile (1940-1942)

As Laurence was very well acquainted with Gilbert Labine of Eldorado, he requested a ton of uranium oxide from him on a loan basis. Ten tons of carbon in the form of calcined petroleum coke was put on order. Workers at the NRC were familiar with the dusty coke through work on problems at the Turner Valley oilfield (Thistle, 1966). The materials were duly delivered and by September 1940 a pile was constructed. In the meantime, the Battle of Britain was raging and the British were developing technical exchange channels with Canada and the still-neutral U.S. In the summer of 1940, R.H. Fowler (who Laurence knew from the Cavendish), was appointed scientific liaison officer to the NRC and the Tizard Mission was sent to the US. As part of the Mission, liaison also took place in Canada and in late November John Cockcroft (returning home from the U.S.) visited the NRC and became familiar with Laurence's pile experiments (Hartcup and Allibone, 1984). He was able to brief Laurence on similar activities by Halban and Kowarski, now in the UK, and by Fermi in the U.S.

As a result of Cockcroft's suggestion, in December Laurence visited Fermi at Columbia and had briefings on the total U.S. program in nuclear research. The trip resulted also in the provision of research reports which were to prove pivotal for Laurence's pile experiments (Laurence, Dec. 1940, derived). In addition, Cockcroft was so impressed that he made arrangements for a research grant of $5000, which arrived in June 1941 from Imperial Chemicals Limited, which was deeply involved in war-related nuclear research (Laurence, 23 June 1941). In December Laurence's expenditures for the pile experiments came to the grand sum of $600 and another $600 was requested to continue the work (Laurence, 17 Dec. 1940).

### 5.1 Pile and Instrumentation Description

The experimental pile and the associated instrumentation, much of which was built by Laurence, is best described by paragraphs extracted from the extensive 42-page report on the experiment (Laurence and Sargent, 1941-1942):

*"The experimental materials were supported in a wooden bin (Fig. 1)* [shown here in Figure 3]*, which consisted of [a] vertical cylinder 140.3 cm. in radius and 270 cm. high. The wooden floor of the bin had the shape of a truncated cone. Thus, when the bin was filled and banked on top in the manner of a heaping teaspoon, the material had approximately the shape of a sphere of radius 140.3 cm. The sidewalls of the bin were 1 in. pine and the floor 2 in. pine. The walls and floor were lined with parafin 7 cm. thick. The upper surface of the material was also covered with wax blocks of this thickness. In one region, the wax wall extended outwards to form an annex 60 cm. square in which the total thickness of wax was 30 cm. ...."*

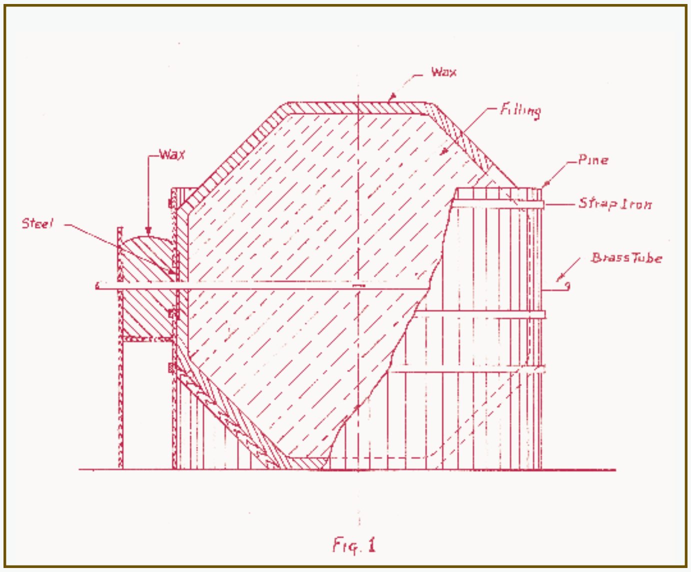



**Figure 3:** Experimental Pile Outline

*"Thin-walled brass tubing extended along a horizontal diameter of the bin from the wax annex to the opposite side. A half-cylindrical copper tray, in length equal to the outer radius of the bin, was used to carry the neutron detector into the brass tube to a chosen position. The continuity of materials in the bin was restored by filling the tray with thin-walled brass cylinders filled with carbon and with wax cylinders."*

*"The carbon used in this experiment was a calcined petroleum coke in the form of a powder packed to a density of about 1.175 gm. per c.c. It was parcelled in paper bags of various sizes, ranging up to 50 lb., for convenience in handling."*

*"The uranium oxide* $U_3O_8$ *had a density of about 3.36 gm. per c.c.*

*and was confined in bags of about 1890 gm. each. In earlier experiments, the pattern of uranium oxide was made up of single bags only with the same average spacing of 16.35 cm. Certain evidence suggested that the quantity of oxide in each unit could be increased to considerable advantage. As the additional quantity of uranium oxide required for doubling the unit was not available, advantage was taken of the fact that the neutron distribution curves, with and without the uranium oxide in carbon, differ very little. The pattern of packages (3780 gm. each) was made to occupy only one-half of the total volume of the bin, being that part defined by two intersecting spheres of radii 133 cm. with centres separated by a horizontal distance of 66.5 cm."*

Figure 4 is a vertical section through the bin depicting the geometry based on the above description showing a honeycomb arrangement of the uranium units in the form of small 12.88 cm diameter spheres, calculated, which are shown as circles.

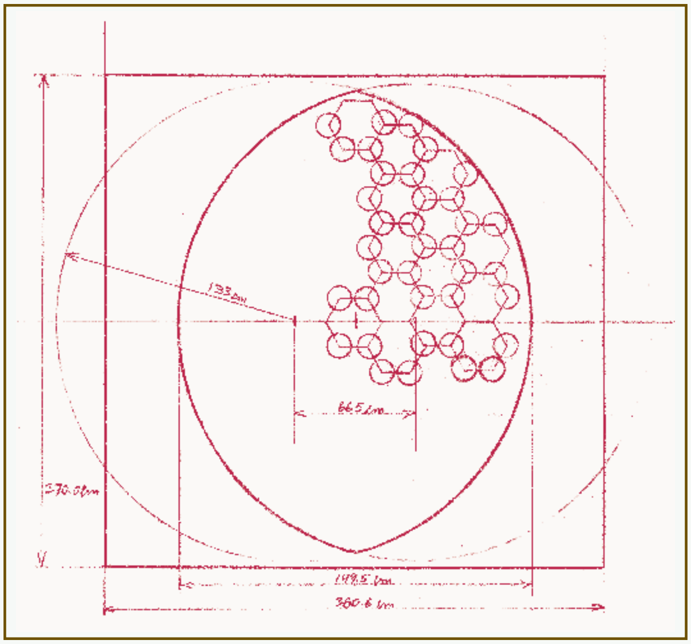


**Figure 4:** Section Through the Experimental Pile

*"The neutron source consisted of 200 mgm. of radium mixed with a few gm. of beryllium, which could be inserted and placed at the centre of the bin through the brass tube. The neutron detector was a layer of dysprosium oxide about 2.5 cm. in diameter and 0.044 gm. per sq. cm. adhering to an aluminum disc. This disc, 3.3 cm. in diameter and 2 mm. thick, was machined to half-thickness over the central area, 2.5 cm. in diameter, to form a depression for the dysprosium oxide. The detector was always placed in the bin with the oxide facing the centre, and exposed to the neutrons for about 17 hrs. each night. The activation was measured by counting the b-rays emitted over a period of 7 hrs. with a Geiger-Muller counter having a thin glass window. A quenching circuit, amplifier and scale-of-eight counting circuit feeding a mechanical counter was used. ..."*

## 5.2 Plotting the data

*"The measurements yielded five [sets of] curves representing the density distribution of thermal neutrons under the different conditions as follows:*

1. *In an approximately spherical bulk of carbon surrounded by a shell of paraffin wax. (Fig. 2)*
2. *In a heterogeneous mixture of carbon and uranium oxide surrounded by the same wax shell. (Figs. 3 and 4)*
3. *In the wax shell when filled with carbon. (Fig. 5)*
4. *In the empty wax shell. (Fig. 6)*
5. *In the wax shell when filled with carbon and uranium oxide. (Fig. 7)."*

The data were used to calculate the regeneration factor (k in modern notation) using two methods, a) the American method, and b) the Halban method. Only the American method will be discussed because in Laurence's opinion it yielded the more correct result because the measurements in the wax shell were inaccurate. Also the method has survived and still is used. Therefore, only Fig. 2 (shown in Figure 5a) and Fig. 4 (actually a re-plot of Fig. 3, shown in Figure 5b) will be discussed here.

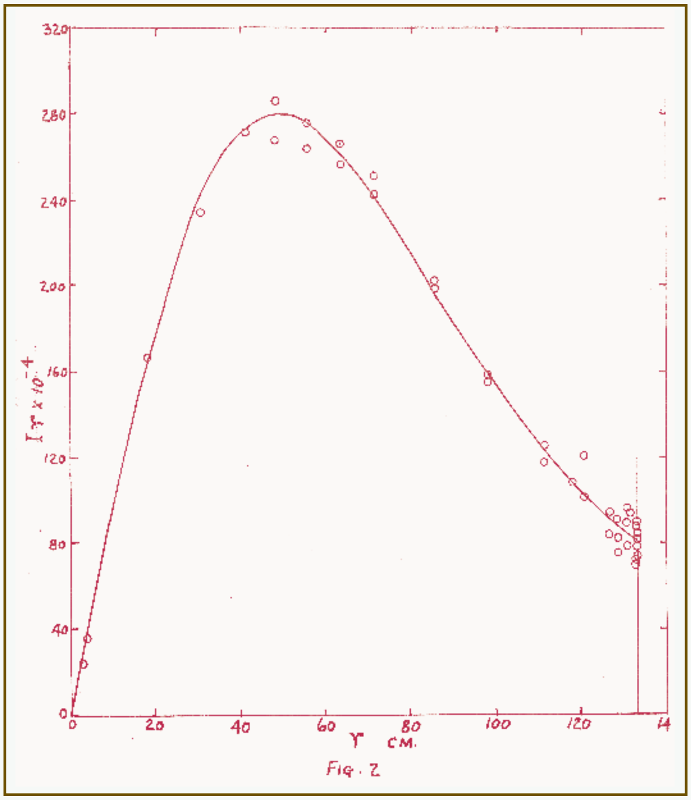



**Figure 5a:** Density-distribution of Carbon in Wax Shell

Both figures are plots of the thermal neutron activity (vertical axis) versus the distance from the source (horizontal axis). The neutron activity is in arbitrary units given in terms of the detector's radioactive intensity, I, multiplied by the square of the distance r from the source squared, in a spherical shell surrounding the source. This presentation methodology was established by Fermi and became customary (Amaldi and Fermi, 1936). A rough explanation of the shape is that initially the neutrons induced little activity in the detector because they had not yet been slowed down, this is followed by an activity peak which then falls off as the distance from the source increases.

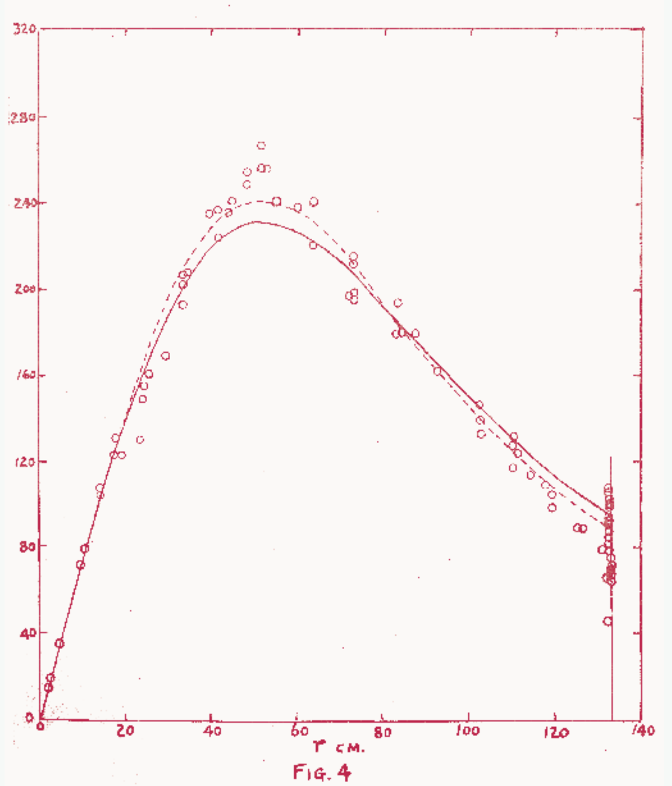



**Figure 5b:** Density-distribution of Carbon-Uranium Mixture in Wax Shell

Figures 5a and 5b show that when uranium is added to the carbon to form a heterogenerous mixture, the peak activity is reduced due to neutron absorption and the tail is raised because more neutrons are present farther from the source. The higher tail is an indication that neutrons were being produced by the uranium itself, i.e., fission reactions were underway, as was first observed by Kowarski in 1940 while experimenting on a heavy-water uranium mixture (Weart, 1979).

## 5.3 Calculations

Having plotted the requisite curves from the measurements, Laurence proceeded to analyze them based on reports covering related measurements ongoing at Columbia, suitably modified as required. This entailed the use of complex mathematical treatments of diffusion theory involving curve fitting (Fisk and Shockley, undated; Fermi and Anderson, 17 Jan. 1941). In the mathematics used, I squared r is expressed in an equation involving a Fourier series containing r and other constants relating to the detector, and $\gamma_\infty$ or the regeneration constant. The curve fitting was done on an iterative basis until a satisfactory solution was arrived at, which in the end converged at a $\gamma_\infty$ of 0.9. However, the analysis of the pile did not stop here.

Using the then-emerging factor models for nuclear reactors, the following equation was written

$$\gamma_\infty = \gamma' f_8 f_u$$

*"in which $f_8$ is the probability that a neutron reaches thermal velocity without suffering resonance absorption in $U_{238}$, and $f_u$ is the probability that a neutron in the heterogeneous system is absorbed by natural uranium. Thus $\gamma^1$ is the average number of fission neutrons produced per neutron absorbed by the uranium".* Again using the reports (Creuts et al., May 29 1942; Fermi, 3 July 1941) from Columbia and with suitable modification, $f_8$ and $f_u$ were estimated to be 0.93 and 0.683, respectively. Thus, with three of the four factors known in the equation, the value of $\gamma'$ works out to be 1.43.

Laurence noted that the value obtained by Fermi (Fermi and Anderson, Jan. 17 1941) was 1.73. In fact Fermi was not satisfied with the 1.73 measurement and he personally performed a repeat experiment (Fermi, July 16 1942) using the purest possible materials and he obtained a value of 1.29. The theoretical value is 1.34 (Weinberg and Wigner, 1958 ) and thus Laurence came up with a fairly good value.

In conclusion Laurence says: *"It would be possible to increase $\gamma_\infty$ by increasing $f_8$ through the use of uranium metal or uranium oxide of higher density. Moreover, $f_u$ and hence $\gamma_\infty$ could be increased if carbon of smaller capture cross-section were used. Part of the capture of thermal neutrons in our carbon is due to hydrogen for its presence was shown by analysis".*

A more modern treatment of the work can be seen in the context of the models given by Kowarski (Kowarski, 1945) and that by Glasstone (Glasstone., 1950) in the equation

$$k = \varepsilon\, p\, f\, \eta$$

where, k is the multiplication factor, ε is the fast fission factor (slightly above 1.0 and frequently about 1.03), p is the resonance escape probability, f is the thermal utilization factor and η is the average number of fast neutrons produced by fission for each thermal neutron absorbed by the uranium. Note that the two equations are practically identical except for ε which would not be that important to the results obtained by Laurence, especially in consideration of the measurement error to which he frequently refers.

In performing the calculations, Laurence established a collaborative relationship with B.W. Sargent, who was teaching physics at Queen's University and whom he had met at the Cavendish. Sargent worked on the calculations during the 1941 and 1942 summer breaks and the fall term of 1942. A considerable correspondence ensued, especially in the fall of 1942 as the two report authors struggled with the mathematical and measurement anomalies (Laurence, 20 Nov. 1942)

# 6. Aftermath

## 6.1 GCL (1942-1987)

In December 1942 Laurence was assigned to the joint British-Canadian Atomic Energy Project at the NRC Montreal Laboratories, where he represented Canadian interests and performed experiments on piles and the design of instrumentation for them. Also Laurence was instrumental in recruiting Canadian nuclear talent to the project which was in very short supply. For his war work he was awarded "The Most Excellent Order of the British Empire" member medal (MBE). In 1945 he became the Scientific Advisor to the Canadian Delegation to the United Nations and in 1946 returned to Canada, to Chalk River where the Montreal Laboratories had moved.

At Chalk River he involved himself with the design of future Canadian reactors and he reviewed the many possible types. He concluded that the reactors should be based on natural uranium and heavy water, i.e., the materials readily available within the country, and technology already familiar to Canadian nuclear workers. In this regard he assumed the role of champion and argued for his preferred reactor type. In some instances he encountered stiff opposition but always managed to overcome it. This type of reactor is that upon which the highly successful Canadian Deuterium Uranium (CANDU) was evolved.

Laurence realized early on that for nuclear electric power to be accepted by the stakeholders (public, government, industry), reactors must be safe and that this could be achieved by design. Thus he conceived a reactor type with three independent systems, a) the process segment, b) the protective segment, and c) the containment system. As a result it would take the failure of all three segments for a release of radioactive material to the environment. This in turn led to a probabilistic risk assessment approach still in vogue today as part of every nuclear power plant design in the western world.

He was a believer in the benefits of physics research and while leading the Atomic Energy Control Board (AECB) from 1961 to 1970 he was, in conjunction with the NRC, responsible for nuclear research in Canada. Much funding was directed toward university research and one of Laurence's greatest achievements was in obtaining funding for the Tri-University Meson Facility (TRIUMF) which is still in operation today.

Recognition of his achievements came with honorary degrees, medals and certificates. In his later years he continued to think, write and speak about various themes involving energy and science in the Canadian context. He gave numerous presentations to younger people demonstrating a deep interest in encouraging them to pursue science and engineering. Laurence passed away at Deep River in November 1987. Recently the AECL named a large building in Deep River the 'G.C. Laurence Hall', in his memory.

### 6.2 The Pile

The location of the laboratories where the pile work was carried out is generally agreed to be in the existing NRC building on Sussex Drive, on the third floor (Bourgeois-Doyle, 2004), which contains rooms large enough to accommodate the pile. Moving 11 tons of material to the third floor must have been a task of considerable magnitude. No photographs of the pile exist. There is no evidence as to the final disposition of the pile material but 11 tons had to be carried down the three floors again.

## 7. Conclusion

Initially, Laurence had a considerable lead on Fermi's group at Columbia, which after a materials measurement program assembled a graphite-uranium lattice pile in July 1941 and identified the need for materials of greater purity to achieve criticality. At this time the piles were on an equal footing but things were to accelerate for the Fermi group while Laurence continued his pile research part-time with few resources.

The U.K.'s Maud report arrived in the U.S. in the summer of 1941 and it proved conclusively that an atomic weapon was feasible and gave a boost to the research underway. The U.S. entered the war in December 1941 and increasing emphasis was placed on nuclear research as Germany seemed to be moving toward obtaining an atomic weapon. Subsequently, the almost unlimited resources of the Manhattan Project ensured that the needed materials and manpower were made available. Finally, at the University of Chicago, Fermi achieved the first critical reactor in December 1942 at about the time the Laurence/Sargent report was completed. The uranium oxide and metal used in this pile also originated at the Eldorado mine at Great Bear Lake.

The pile research pursued by Laurence is an outstanding example of how researchers, working independently, can arrive at similar conclusions nearly simultaneously. This pile was the first of its kind to demonstrate nuclear fission and served as the prototype for certain reactor designs that today, in some countries, produce electricity for the benefit of their citizens.

It is understood that some research may be undertaken to explore Laurence's pile using contemporary simulation tools. The results of such an exercise should help to illuminate further the state of knowledge possessed by the pioneers of nuclear science.

## 8. Acknowledgments

The author would like to thank Lyn Arsenault for research support and patient editing in the preparation of this article. I am very indebted to Patricia (nee Laurence) and Stuart Buchanan at Deep River, who allowed access to the personal papers of George Laurence in their home, previously the family home of GCL. Stephen Leclair, Archivist at the NRC provided early photographic material from the archives. Ben Rouben provided a number of references that made untangling the nuclear science of the 1940s possible. And as always, Fred Boyd provided valuable assistance in pulling the article together.

## 9. References

Amaldi, E. and E. Fermi. On the Absorption and the Diffusion of Slow Neutrons, 1936. In: Fermi, E. Collected Works, Vol. 2. University of Chicago, Chicago, Ill. 1962.

Bourgeois-Doyle, Richard I. George J. Klein: The Great Inventor. NRC Research Press, Ottawa. 2004.

Brown, Andrew. The Neutron and the Bomb: a Biography of Sir James Chadwick. Oxford University Press, Oxford, U.K. 1997.

Carmichael, Hugh. "Biography of Dr. George Craig Laurence". Transactions of the Royal Society of Canada, Series V, Volume IV. 1989.

Cathcart, Brian. The Fly in the Cathedral: How a Group of Cambridge Scientists Won the International Race to Split the Atom. Ferrar, Straus and Giraux, New York, N.Y. 2004

Creuts, E. C., R.R. Wilson, and E.P. Wigner. Absorption of Resonance Neutrons by Spheres of Uranium. June 1 1941, and A-163, May 29 1942, Columbia University, New York, N.Y.

Dahl, Per F. Heavy Water and the Wartime Race for Nuclear Energy. Institute of Physics Publishing, Bristol. 1999.

Fermi, E. and H.L. Anderson. Production and Absorption of Neutrons by Uranium. A-6, Jan. 17 1941, Columbia University, New York. N.Y. Also in: Fermi, E. Collected Works, Vol. 2. University of Chicago, Chicago, Ill. 1962.

Fermi, E. and G.L. Weil. The Absorption of Thermal Neurons by a Uranium Sphere Imbedded in Graphite. A-1, July 3 1941, Columbia University, New York. N.Y. Also in: Fermi, E. Collected Works, Vol. 2. University of Chicago, Chicago, Ill. 1962.

Fermi, E. The Number of Neutrons Emitted by Uranium per Thermal Neutron Absorbed. Report C-190, July 16 1942, University of Chicago. Also in: Fermi, E. Collected Works, Vol. 2. University of Chicago, Chicago, Ill. 1962.

Fisk, J.B. and Schockley, W. A Study of Uranium as a Source of Power. Parts I, II, III, IV. Undated. [Reference in: Laurence and Sargent, 1941–1942].

Glasstone, Samuel. Sourcebook on Atomic Energy. Macmillan and Co. Limited, London, U.K. 1950.

Glasstone, Samuel. Principles of Nuclear Reactor Engineering.. D. Van Nostrand Co. Inc., Toronto, Ont. 1955.

Hartcup, G. and T.E. Allibone. Cockcroft and the Atom. Adam Hilger, Ltd., Bristol, U.K. 1984.

Kowarski, L. "Introduction to Pile Theory". Lecture No. 8 from Notes on Lectures Given in Montreal Training Course. 13 August 1945. Public Records Office, Kew, U.K., AB2/870.

Laurence, G.C. and Edith Quimby. The Measurement of Dose in Roentgen Therapy. Radiological Society of North America. 1939.

Laurence, G. Notes: Nuclear Fission Research in the United States. December 1940 (derived).

Laurence, G. Letter to R.W. Boyle. Re: Uranium Investigations. 17 December 1940.

Laurence, G. Letter to J. Cockcroft. No subject. 23 June 1941.

Laurence, G.C. and B.W. Sargent. Uranium Fission in a Bulk of Carbon and Uranium Oxide. National Research Laboratory, Ottawa, Ont. 1941–1942.

Laurence, G.C. Memo to B.W. Sargent (No subject). 20 Nov. 1942.

Laurence, G.C. "Canada's Participation in Atomic Energy Development." Bulletin of Atomic Scientists, Vol. 3 No. 11, November 1947.

Rutherford, Ernest. Radio-activity. Cambridge University Press, Cambridge, U.K. 1904.

Sargent, B.W. "Nuclear Physics in Canada in the 1930s." Invited paper delivered at the History and Philosophy of Science Conference held at McGill University. September 20-21, 1979.

Serber, Robert. Peace and War: Reminiscences of a Life and the Frontiers of Science. Columbia University Press, New York, N.Y. 1988.

Thistle, Mel. The Inner Ring: The Early History of the National Research Council of Canada. University of Toronto Press, Toronto, Ont. 1996.

Weart, Spencer R. Scientists in Power. Harvard University Press, Cambridge, Mass. 1979.

Weinberg, Alvin M. and Eugene P. Wigner. The Physical Theory of Neutron Chain Reactors. The University of Chicago Press, Chicago, Ill. 1958.

Wiles, Donald R. The Chemistry of Nuclear Fuel Waste Disposal. Polytechnic International Press, Montreal, Que. 2002.




*30th Annual Conference of the Canadian Nuclear Society*
*33rd CNS/CNA Student Conference*

# Design and Installation of a Strategically Placed Algae Mesh Barrier at OPG Pickering Nuclear Generating Station

by D. Marttila[1], P. Patrick[1] and C. Gregoris[2]

*[**Ed. Note:** This paper was presented at the 30th annual conference of the CNS]*

## Abstract

Ontario Power Generation's Pickering Nuclear has experienced a number of events in which attached algae have become entrained in the water intake costing approximately $30M over the 1995-2005 period as a result of deratings, Unit shutdowns and other operational issues. In 2005-2006 OPG and Kinectrics worked collaboratively on evaluating different potential solutions to reduce the impact of algae on the station. One of the solutions developed by Kinectrics included a strategically placed barrier net designed to regulate algae flow into the station intake. In 2006, Kinectrics designed and installed the system, the first of its kind at a Nuclear Power Plant in Canada. The system was operational by May 2007. OPG completed an effectiveness study in 2007 and concluded the barrier system had a beneficial effect on reducing algae impact on the station.

## 1. Introduction

Ontario Power Generation (OPG) is an Ontario-based electricity generation company whose principal business is the generation and sale of electricity in Ontario. OPG is one of the largest power generators in North America providing a total capacity of over 22,000 megawatts (MW) [1]. OPG owns and operates 3 nuclear generating stations including Pickering Nuclear Generating Station (PNGS) located on the shores of Lake Ontario just east of Toronto in Pickering. Pickering NGS consists of Pickering A and Pickering B together generating 3,100 megawatts (MW), making it one of the world's largest nuclear generating facilities [1]. Maintaining reliable production from this facility is critical to meet customer demands.

Ontario Power Generation's Pickering B Generating Station has experienced a number of events in which algae, predominantly *Cladaphora*, has become entrained in the water intake causing operating problems ranging in severity from unit load reduction to complete station shutdown [2]. During the eleven year period from 19952005, generation losses related to algae for Pickering B were estimated to be roughly $29.7M or $2.9M per year on average [3] (refer to Table 1). This prompted OPG to take a proactive approach in addressing the problem.

Since 2005, OPG and Kinectrics have worked collaboratively on a number of initiatives to better understand the algae problem and to develop solutions to mitigate it. One of the solutions discussed was a strategically placed barrier net off the east groin of the intake channel to reduce algae influx into the station that primarily originates from the east (approximately 80%). In 2006 Kinectrics designed and installed an algae mesh barrier at Pickering NGS ma king it the first at a Nuclear Power Plant in Canada.

| Period | Gross Production Losses(MWh) | $ Loss Due to Algae |
|---|---|---|
| 1995 | 294,557 | $14,580,554 |
| 1996-2000 | 81,816 | $4,049,892 |
| 2001 | 49,715 | $2,460,885 |
| 2002 | 4,660 | $230,694 |
| 2003 | 36,028 | $1,783,403 |
| 2004 | 8,227 | $407,258 |
| 2005 | 126,749 | $6,274,094 |
| TOTAL | 601,752 | $29,786,781 |

**Table 1** Generation Losses at Pickering B 19952005 [3]

This report provides background on the algae problem at Pickering Nuclear, and discusses the major design features of the algae mesh barrier solution. In addition, the effectiveness of the system during the first year of operation is discussed.

## 2. Background

### 2.1 Statement of Algae Problem

In warm weather conditions algae growth in Lake Ontario becomes elevated and certain wind conditions can cause large influxes of detached algae to enter the station's water intake systems. When this occurs it is defined by the station as an algae run. The ability of the station to cope with an algae run depends on the volume of algae and the duration of the event. The station is better equipped to handle a slow and steady algae run, as opposed to an event where the same volume enters the plant over a shorter period of time [4]. Wind speed and direction are the key environmental factors that determine the magnitude of the algae run, and can vary significantly from day to day especially during storm events.

When algae enters the station, it accumulates on the travelling screens and filters threatening the cooling capacity necessary for the station's turbine condensers. The threshold of the screen house equipment to handle algae depends on its condi-

1 Kinectrics Inc., Toronto, Ontario, Canada
2 Ontario Power Generation, Pickering, Ontario, Canada

**Figure 1** *Cladophora* (attached algae).

tion, an optimally maintained screen house will have a higher threshold than a poorly maintained one [5]. When the threshold is exceeded, the pressure differential increases and the screens become overloaded and trip [5]. When this occurs, the capacity of the cooling water is reduced forcing the station to derate power output. This is defined by the station as an algae event and can have a serious impact on lost revenue (Table 1).

Since 1972, there have been at least 42 events at Pickering when algae, predominantly *Cladophora* (Figure 1), has caused operating problems ranging in severity from unit load reduction to complete station (4 unit) shutdown [2]. Twentyfive of the 42 events have occurred in the last five years (2001 to 2005), with 15 in 2005 alone. In general, algae incidents occurred in the later part of the year, August through December, although some events have occurred earlier in the year (eg June 1995 and May 2001) [2].

### 2.2 Algae Characteristics at Pickering NGS

As shown in Figure 2, algae distribution from east to west of Pickering NGS is predominantly along the shoreline [6]. According to the airborne CASI image, the algae density along the shoreline ranges from 32 g/m2 to 190 g/m2 (dry weight). The density appears to reach its maximum closer to shore (shallower) and declines as water depth increases.

In 2005-2006, OPG and Kinectrics worked collaboratively on an investigative study to understand the movement patterns of algae following detachment. An evaluation of the environmental conditions were reviewed prior to and during each algae event including wind speed and direction, lake current speed and direction, and lake temperatures. The results of the study indicate the wind direction during algae events is predominantly from the north east direction at speeds over 20 km/hr (80%), and lake current direction is from east/north east for 100% of events reviewed [4]. More recent data concluded that the key environmental factors are wind and current direction, and the majority of algae events occur when algae runs are from the east [4].

The information captured during the investigative study allowed OPG and Kinectrics to better evaluate design solutions for reducing the impact of algae on the station.

## 3. Algae Mesh Barrier Solution

In 2005-2006 OPG and Kinectrics evaluated a number of design solutions to address the algae issue. One of the solutions considered was a barrier net placed across the intake structure. Mesh barriers are used extensively in the US to reduce fish impingement at Power Plants as part of the USEPA regulation 316(b). The systems in place are in a wide variety of operating environments from protected water areas to harsh lake conditions (i.e. Lake Michigan). Although they are primarily used for fish impingement, they are reported to be effective at trapping debris such as algae.

The idea of placing a mesh barrier across the intake structure at Pickering Nuclear was rejected due to the high flows in the intake channel (greater than 2fps). A unique approach to this solution was to strategically place the net, at a location where the algae originates from (and lower flows), so as not to jeopardize the safety of the station from the consequences of net breakage.

As discussed in Section 2.2, algae events originate predominantly from the east. Preliminary analysis suggested that a mesh barrier positioned off the east groin of the intake channel would result in an algae reduction of 30% or higher from entering the station. This technology was reviewed by OPG along with other solutions such as equipment enhancements and operational changes [2]. The solutions were evaluated against a number of criteria including installation cost and estimated effectiveness. The algae mesh barrier was a preferred option for Pickering NGS due to its relatively low cost and moderate estimated effectiveness. In addition, the solution could be installed and operational very quickly without station interruption. This solution was to be considered as a trial or experimental basis, with the intent that the net could be extended if preliminary results indicated a reduction in algae influx.

The principle of the net operation is to delay or regulate the flow of algae into the station. As discussed in Section 2.1, the station can cope better with a slow and steady algae run as opposed to a sudden quick algae run of the same volume. As the net becomes loaded with algae, it was anticipated that the algae will pass through the net, move around it, or be redirected towards the east when the wind direction changes [6]. In each case, the net is expected to have a positive impact on the station.

Kinectrics submitted a proposal to OPG in September 2006 to design, supply, and install a strategically placed algae mesh barrier off the east groin of the Pickering intake channel. OPG prepared a business case based on the estimated algae reduction and decided to proceed with the solution immediately (September 2006).

### 3.1 Project Overview

In September 2006, Kinectrics was awarded a contract to design, supply, and install an 85m (280ft) mesh barrier net system off the east groin at Pickering NGS. The use of a mesh barrier to regulate (delay) algae flow into a nuclear power plant intake was the first of its kind in Canada. The main objectives of the project included:

- Determine the optimal net design and placement to reduce algae influx into the station
- Perform a risk assessment including consequential analysis of failure of the barrier net design
- Obtain all necessary approvals for installation including regulators, OPG internal approvals
- Safely install the barrier net
- Evaluate effectiveness

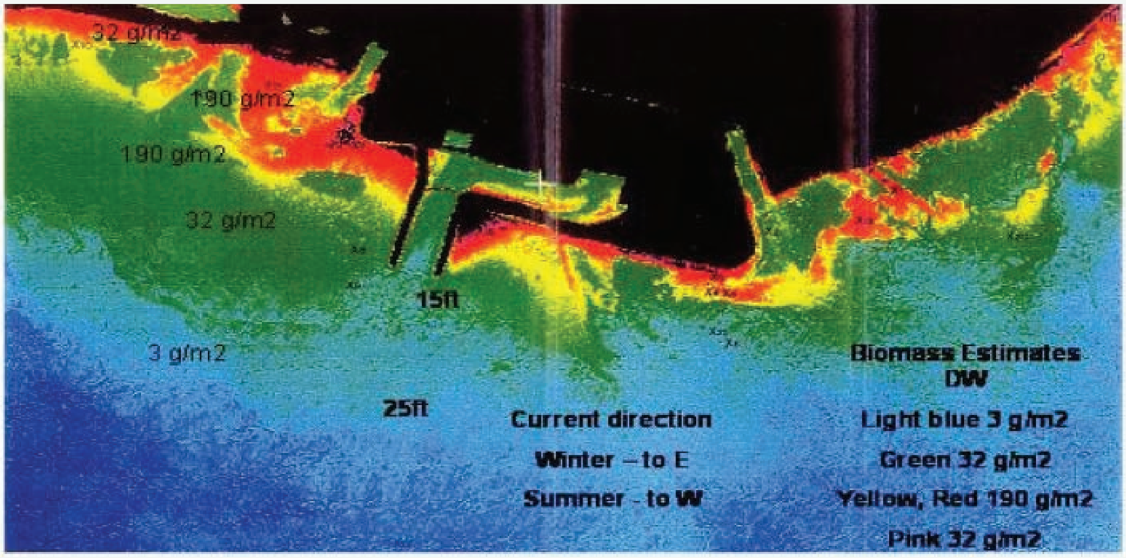



**Figure 2** CASI image of Pickering station showing areas with *Cladophora* [6]

## 3.2 Engineering Design

The design process was complex and required meeting a series of design requirements that included engineering constraints (civil, mechanical, hydraulic), nuclear safety, public safety, and regulatory approvals including the Department of Fisheries and Oceans, Ministry of Natural Resources, and Transport Canada. The design also required the net to be easy to install, remove, maintain, and clean on a regular basis. The final design underwent an extensive risk assessment to ensure the design would have no negative impact on station operations.

As part of the engineering design, Kinectrics reviewed similar systems in the US through extensive discussions with suppliers and engineers at power plants, and site visits to utilities in the US who currently operate barrier nets (i.e. Consumer's Energy in Ludington Michigan who have been operating the system for over 20 years).

The major design tasks for the algae mesh barrier system included determining the optimum design of the following:

- Positioning of Net
- Net Panel
- Piling and Connection

### 3.2.1 Positioning of Net

The optimum location of the net was determined to be off the east groin of the Pickering intake channel, as the source of algae is predominantly from the east. To determine the proper orientation of the net, hydraulic modeling was completed on several options. Hydraulic modeling also verified that under worst case conditions with the net fully blocked, the net would not pose a safety risk to the station such as restricting cooling water supply. The model included evaluating net orientations of 30˚, 45˚, 66˚, 90˚, and 135˚ under worst case conditions (0% porosity, no cleaning/maintenance). The model results were expressed for different flow conditions (0.5, 1.0 and 2.0 ft/s) with currents approaching from either the east or west [7]. A storm scenario was assumed to occur when the flow approached the groins at 2.0 ft/s (flow in the intake channel is approximately 2.5 ft/s). The results of the modelling report [7] suggested the following:

- The 45˚ orientation off the east groin was considered the preferred option for net placement (refer to Figure 4). This orientation achieved a high collection zone with flows from the east but there was less risk with erosion (attached algae entering the station from around the net) compared to other simulations such as the 90˚ angle or no net cases (refer to Figure 3).
- There is no increase in risk to the station with the addition of a net relative to present conditions. There was also no evidence of negative environmental impacts with a net in place on the east groin.
- Results with a net porosity of 75% more closely resembled that of a fully clogged net than the no net case when the flow approached from the east. In all cases, there was a reduction of the area of the recirculating region.

### 3.2.2 Net Panel Design

To provide 85m coverage, a total of 9 net panels were designed to cover the span including 8 'standard' net panels and 1 wedge net panel which connects to the groin. The 8 standard net panels are roughly 7.6m (25ft) wide and the wedge net panel 24m (80ft) wide. Each net panel is designed to accommodate 110% of high water level plus a 1m (3ft) wave. The additional height of the net allows the barrier to stretch out allowing coverage of the water column during rough water conditions (waves <1m). Each net panel has a single float line designed to keep the net panel buoyant. As the net becomes loaded with algae the floats begin to submerge, signaling the station that cleaning may be required.

The mesh size of each net panel is 3/4" (bar) made of #18 Dyneema® twine (1.7mm diameter). Dyneema® is an extremely robust material rated up to 15 times stronger than steel and up to 40% stronger than arami d fibers, both on weight for weight basis [8]. The most

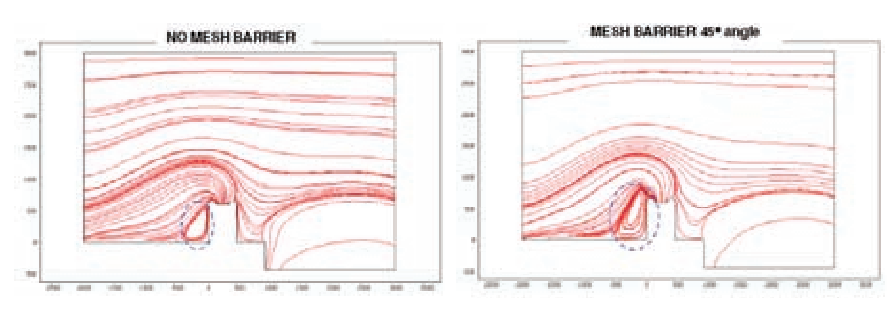



**Figure 3** No Mesh Barrier in Place (left), Mesh Barrier 45° off of East Groin [7]


**Figure 4** Barrier Net Location and Orientation

common mesh sizes used in the US for fish impingement are 1/2" and 3/4" (bar), and both sizes have the effect of trapping algae. The function of the net is to delay the flow of algae through the net and thus the larger 3/4" mesh size was selected.

The framing lines of the net provide the structural integrity of the net system. The perimeter of each net panel is outfitted with 5/8" Dyneema® rope. A 1/2" long link chain is sewn directly into the bottom framing line, which is designed to keep the net weighed down on the lake bottom.

#### 3.2.3 Piling and Connection Design

A total of nine steel pipe piles (12") embedded into the lakebed provide the mounting structure for the net system. Each standard 7.6m net panel is fastened between a set of steel pipe piles spaced approximately 7.6m apart. The piles protrude above the lakebed and are roughly 2m below the lake surface to avoid ice issues and navigational hazards. The connections between each pile and net are made using standard marine shackles. These are relatively easy to install and remove underwater by divers. Refer to Figure 5 for an illustration of the net system and how it is connected.

A marker buoy is connected to the net at each pile location (9 buoys). Each buoy is outfitted with a solar light in order to comply with the relevant marine transportation requirements.

#### 3.2.4 Groin Connection

To form a complete seal between the net system and the groin (armourstone), a wedge net panel was designed to connect directly to the groin and the first pile. The first pile was installed as close to the groin as possible at approximately 13m (40 ft). The wedge shaped net was connected to the first pile and the groin where it is connected by a chain to a set of concrete anchors installed on top of the groin. Figure 5 shows an illustration of how each net panel is integrated into a continuous net system. It also shows the wedge shaped net panel that connects to the groin of the intake channel.

### 3.3 Summary

The 85m algae mesh barrier was installed in May 2007, at a 45 degree angle off the Pickering NGS east intake groin (Figure 6). The barrier net was inspected, cleaned, and repaired as necessary during its first season in operation and removed in December 2007.

### 3.4 Estimated Effectiveness

According to a report prepared by OPG, the algae mesh barrier had a beneficial effect on Pickering NGS during its first season in operation in 2007 [6]. This report analyzed the effectiveness of the net for algae traveling near the shoreline from the east towards the station. Various methodologies were used to determine the effectiveness of the barrier net including an assessment of algae material accumulating in front of it, screen house bin data, and the results from a Radiotag Release and Tracking Study completed by Kinectrics (2007), which focused on the number of released tags collected by the net [6].

The key points outlined in the evaluation report [6] are listed below:

- Effectiveness appeared to be variable during the season depending on environmental factors (wind speed and direction, etc.).
- Highest effectiveness was observed in August when algae detachment occurred. The effectiveness during this period for algae traveling near the shoreline from the east towards the station was estimated to be 30%.
- The net appeared to be most effective during short algae runs lasting only a few days (48%), while effectiveness dropped for events lasting 10 days or longer (15%) [6].
- After the detachment period in August, effectiveness declined. After October no algae accumulation was observed.
- Generation losses at Pickering B in 2007 related to algae, could not directly be linked to net behaviour, as many factors influence algae related losses such as screen house equipment condition.
- The RadioTag Release and Tracking study concluded the barrier net is in a good location, allowing the net to interact with 67% of algae traveling near the shoreline from the east.

The effectiveness of the algae mesh barrier during its second season in operation has not yet been determined.

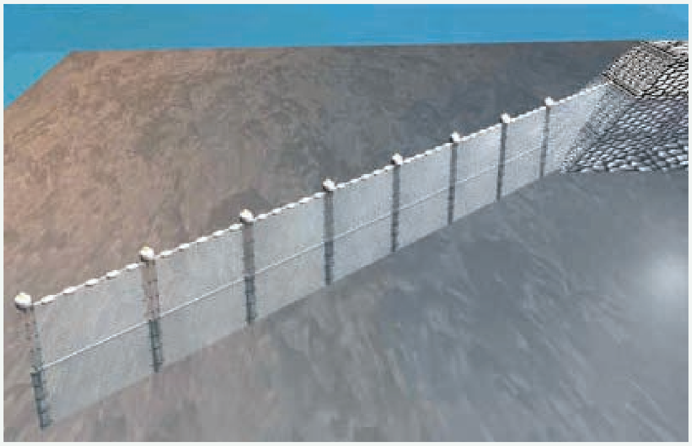


**Figure 5** Diagram of Net System with Typical Net Panels and Groin Connection


**Figure 6** Diagram of Net System with Typical Net Panels and Groin Connection [6]

### 3.5 Lessons Learned

During the first two seasons of operation, OPG and Kinectrics have gained extensive knowledge and experience related to the design, operation, and maintenance of the algae mesh barrier system. During this time a number of lessons learned have been identified including the following:

- *Extension of net system for improved effectiveness:* It is expected that the effectiveness of the system can be enhanced by extending the net further south by at least 100m.
- *Reduced cleaning requirements:* Through two years of operation, the net has behaved as a 'selfcleaning' system, where algae attached to the net is removed and washed away during high wind or storm events.
- *Maintenance procedures:* Routine maintenance and repair of net panels are completed insitu by divers on a weekly basis (weather pending). This minimizes the risk of net panels havi ng to be removed for major rework.
- *Managing height of net panel with fluctuating lake levels:* The net panels are designed to accommodate high water level plus a 1m wave. As a result, in low water levels the netting has a tendency to gather slack at the lake bottom making it a potential wear area for the net. Kinectrics addressed this in the design by keeping the slack suspended in the water column using a buoy system. There are other solutions that may be considered as well such as the addition of a second float line to the net panel.

## 4. Conclusion

Kinectrics safely installed the algae mesh barrier in May 2007. During its first year in operation, the net was considered to be effective at reducing the impact of algae runs on the station. The net just concluded its second season in operation (MayDecember 2008), and an extended net is expected to be installed again in May 2009 to address not only algae but fish impingement.

During the first two years in operation, OPG has gained significant operational experience and has identified a number of potential areas for improvement. One option to increase effectiveness is to extend the current net further into Lake Ontario [6]. This would increase the coverage area for regulating algae flow into the station from the east. There is also a desire to further understand the behaviour of algae through initiatives such as source and movement studies, algae growth and accumulation measurements, and screen house bin data collection and content analysis [6].

OPG and Kinectrics continue to work together on initiatives focused on improving the understanding of the algae problem and reducing the impact on the station.

## 5. References

[1] Ontario Power Generation, "About OPG", (http://www.opg.com/about/), 2009

[2] G.P. Arron, P.H. Patrick, "Optimization of existing plant and intake water quality – Pickering B NGS – integration of solutions to algae problem", Kinectrics Report K-100042-001-RA-0002-R02, Toronto, Ontario, Canada, 2006, pp.1

[3] P.H. Patrick, B. Reesor, D.D. Ager, "Fish diversion options for Pickering Nuclear Generating Station: cot option analysis", Kinectric Report K-409013-001-RA-0002-R00, Toronto, Ontario, Canada, 2008, pp.14

[4] G.P. Arron, F. Camacho, "Development of the algae run risk assessment (predictive) tool at Pickering Nuclear", Kinectrics Report K-012873-001-RA-0001-R01, Toronto, Ontario, Canada, 2007, Appendix 7

[5] R. Hester, "Evaluation of the feasibility of an advance warning system to identify an impending influx of detached filamentous algae onto station screening equipment at Pickering Nuclear", OPG Report No. P-REP-07015.04-00001, Pickering, Ontario, Canada, 2002

[6] B. Kyte, "Algae barrier net effectiveness review for 2007 season", OPG Report No. P-REP-23200-00012-R00, Pickering, Ontario, Canada, 2008, pp.1

[7] M.J. Schertzer, R.B. Mrad, "Effective of net orientation on flow past inlet groins", Kinectrics Report K-013144-001-UofT-TM-0001-R00, Toronto, Ontario, Canada, 2006

[8] DSM-Dyneema®, Dyneema®, the world's strongest fiber™, http://www.dsm.com/en_US/html/hpf/home_dyneema.htm, 2009

*30th Annual Conference of the Canadian Nuclear Society*
*33rd CNS/CNA Student Conference*

# ACR-1000® Environmental Performance Design Improvements

by M. Sachar[1], S. Julien[1] and K.Hau[1]

*[**Ed. Note:** This paper was presented at the 30th annual conference of the CNS]*

## Abstract

The ACR-1000®design is the next evolution of the proven CANDU® reactor design. One of the key objectives for this project was to improve station environmental performance based on the As Low As Reasonably Achievable (ALARA) principle, and station operating experience, feedback from owners of CANDU stations, and industry best available techniques. Design improvements, based on these concepts to improve the environmental performance of the ACR-1000 reactor and protect workers, the public, and the environment, are presented in this paper.

## 1. Introduction

Atomic Energy of Canada Limited (AECL) has established a successful, internationally recognized line of CANDU[2] pressurised heavy water reactors (PHWR) that use a heavy water moderator, in particular, the medium-sized CANDU 6 reactor. AECL has consistently adopted an evolutionary approach to the enhancement of CANDU nuclear power plant designs over the last 30 years. The current CANDU 6 reactor design has been developed further in the market-ready Advanced CANDU Reactor (ACR) reactor design.

The ACR-1000[3] design has evolved from AECL's in-depth knowledge of CANDU structures, systems, components, and materials, as well as from the experience and feedback received from owners and operators of CANDU plants. The ACR-1000 design features significant environmental performance improvements based on the As Low As Reasonably Achieveable (ALARA)[4] principle while retaining the proven benefits of the CANDU family of nuclear power plants.

### 1.1 Scope

This paper summarizes the design aspects of the ACR-1000 reactor that contribute to improving the environmental performance of the nuclear power plant (NPP) by ensuring that radionuclide production and release mechanisms are minimized. This paper also describes the ALARA principle and how it was applied to the design of those systems and processes of the ACR-1000 reactor that impact environmental performance and which protect workers, the public, and the environment.

## 2. Source terms

For NPPs, environmental performance is determined by measuring the airborne and waterborne radionuclides described below. These radionuclides are closely monitored and controlled by operating CANDU NPPs [1], and in the ACR-1000 NPP, by several systems that have a direct impact on the environment.

### 2.1 Airborne source terms

1. Tritium ($^{3}H$)

   Tritium is produced primarily by neutron activation of deuterium in the reaction $^{2}H(n,\gamma)^{3}H$ in heavy water contained in the reactor core of a CANDU NPP. Tritium is also produced from the lithium added to the coolant for chemistry control through the $^{6}Li(n,\alpha)^{3}H$ reaction.

2. Carbon-14 ($^{14}C$)

   Carbon-14 is produced in the moderator and moderator cover gas of a CANDU reactor via a $^{17}O(n,\alpha)^{14}C$ reaction due to the high thermal neutron fluxes in the reactor core. Carbon-14 is also produced in small quantities in the annulus gas system in the $^{14}N(n,p)^{14}C$ and $^{17}O(n,\alpha)^{14}C$ reactions from traces of nitrogen and oxygen present in the carbon dioxide annulus gas system cover gas. A small amount of $^{14}C$ is also produced by the $^{17}O$ present in the uranium dioxide fuel.

3. Radioiodines (e.g., $^{131}I$)

   Radioiodines are fission products that may be present in the coolant of the heat transport system of a CANDU reactor. They are generated by fission in the uranium fuel and are retained within the individual fuel element of the fuel bundles unless there is a fuel element sheath failure that may release in radioiodine releases to the heat transport system coolant. If there are no fuel element sheath defects, then there are essentially no radioiodines in the heat transport system coolant. Any defective bundles would be detected and removed on-power and therefore there are normally very low radioiodine inventories present in the heat transport system coolant.

---

1 Atomic Energy of Canada Limited, Mississauga, Ontario, Canada

2 CANDU® (CANadian Deuterium Uranium®) is a registered trademark of Atomic Energy of Canada Limited (AECL), 2009

3 ACR-1000® (Advanced CANDU Reactor®) is a registered trademark of Atomic Energy of Canada Limited (AECL), 2009.

4 ALARA: As Low As Reasonably Achievable, social and economic factors taken into account.

4. Noble Gases
   Argon-41 is generated from the $^{40}Ar$ impurities in the helium of the moderator cover gas and in the carbon dioxide of the annulus gas system of a CANDU reactor. It is also generated in the heat transport system by the activation of argon impurities in air that enters the system.

   Fission product noble gases, including radioisotopes of xenon and krypton, which are generated as fission products in the uranium fuel and are contained by the fuel sheath, may also be present in the heat transport system. The release of fission product noble gases to the heat transport system coolant is governed by the same process as for radioiodines.

5. Particulates
   In a CANDU reactor, particulate originates as corrosion and activation products from the heat transport system as well as from fission products, the calandria shell, calandria tubes, and the operation of reactivity devices.

To monitor and control airborne radionuclides, process systems in the ACR-1000 reactor vent air to the ventilation system which is used to collect exhaust air from all areas of the plant. The exhaust air from eight major streams in the reactor building (fuel off-gassing hood, spent fuel magazine, pressure and inventory control degasser condenser and coolant storage tank, heat transport system leakage collection tank, and fuelling machine water system) is then passed through the gaseous waste management system. The gaseous waste management system incorporates a filter train and the off-gas management system to purify the air. The filtration system includes high-efficiency particulate air filters and charcoal filters to remove particulate and radioiodines, respectively. The off-gas management system increases the residence time of the air by delaying its passage to the stack to allow for the decay of noble gases.

To monitor and control airborne heavy water, the heavy water systems located in the maintenance building and reactor building are atmospherically separated and vented to a vapour recovery system such that the heavy water can be captured and recycled.

Figure 1 illustrates the ventilation and vapour recovery pathways for the ACR-1000 reactor.

## 2.2 Waterborne source terms

1. Tritium ($^{3}H$): See Section 2.1 for a description of $^{3}H$ source terms.

2. Carbon-14 ($^{14}C$): See Section 2.1 for a description of $^{14}C$ source terms.

3. Gross beta-gamma: In a CANDU reactor, gross beta-gamma consists of fission and activation products that are not classified in any of the other categories. Mass transport and solution-dissolution mechanisms result in the activation of corrosion products in the reactor core and their deposition in various parts of the circuit, or suspension in the coolant.

Light water, which is used in the ACR-1000 reactor process systems, is collected in the drainage systems and processed in the radioactive liquid waste management system. The radioactive liquid waste management system has improved segregation of liquid streams at source and throughout processing and storage. The system is designed to collect water from all systems in the NPP and purify it to remove contaminants. All purified water is monitored to ensure that purification requirements are consistently being achieved.

Figure 2 illustrates the drainage pathways.

# 3. ALARA design principle

The ALARA principle ensures that a system within the NPP is designed with emphasis on radiation protection for workers, the public, and the environment, and the minimization of radionuclide production and release mechanisms.

The design of the CANDU family of NPPs, and specifically the ACR-1000 reactor, conforms to the ALARA principle by ensuring that the design option was selected to minimize the environmental impact, while taking into account a wide range of factors including technological maturity, availability and reliability, operational safety, radiation protection, and social and economic factors.

To apply the ALARA principle to ACR-1000 systems that have a direct impact on the environment, a best available technique (BAT) assessment was conducted. The basic principles for determining a BAT involve identifying options, assessing environmental effects and considering economics. The principles of precaution and prevention are also relevant factors in BAT determinations.

The BAT methodology includes analysis of technically and economically feasible alternatives, a cost-benefit analysis of potentially adverse environmental effects of each feasible alternative, and a scoring system to evaluate each alternative. Reasons for selection of the proposed option including justification for rejection of other alternatives must be documented.

The BAT assessment demonstrated that process and technology alternatives had been considered and assessed in the systems' design, and that the best approach overall was selected for minimizing the impact of the ACR-1000 reactor on the environment.

# 4. ACR-1000 design improvements

Significant environmental performance improvements are inherent in the ACR-1000 design:

- Light water is used as coolant and for the entire fuel handling process instead of heavy water.
- Low enriched uranium is used in the fuel instead of natural uranium lowering the thermal neutron flux in the core.
- The lattice pitch in the reactor core is reduced contributing to a more compact reactor design and less heavy water in the reactor core.

These design changes minimize the use of heavy water in the ACR-1000 reactor and decrease the thermal neutron flux in the reactor core, which leads to a decrease in the production of $^{3}H$ and $^{14}C$.

Additional environmental performance design improvements, which have been applied to the ACR-1000 reactor design, are summarised below. The improvements are categorised based on their importance to source term reduction for the most significant radionuclides; 3H and 14C. Environmental performance design improvements, which impact on the other airborne and waterborne source terms, are discussed separately.

## 4.1 Tritium

1. Lithium depleted to 0.1% $^{6}Li$ is used for chemistry control in the heat transport system reducing the formation of $^{3}H$ from the $^{6}Li(n,\alpha)^{3}H$ reaction in the reactor core.

2. The design of the reactor building ensures control over moderator heavy water through the relocation of all heavy water related systems (moderator purification system, moderator cover gas system, moderator poison system, liquid injection shutdown system, and deuteration/dedeuteration system) inside dried areas of the reactor building, with increased reactor building moderator dryer capacity using rotary desiccant wheel dryers. Also, to prevent downgrading of heavy water and minimize the heavy water upgrading requirement from the reactor building, the ACR-1000 design has incorporated dryers at the inlet to the reactor building ventilation system to minimize the migration of light water into dried areas.

   Furthermore, the reactor building vapour recovery system has been designed as a two-loop system, which ensures atmospheric separation between the reactor building moderator room and reactor building moderator auxiliary room (See Figure 1). This ensures that air from the two rooms does not mix, since the moderator room is expected to contain higher levels of tritium activity and this source can be processed separately.

   A BAT assessment was conducted for the reactor building vapour recovery system to determine the best process to reduce airborne $^{3}H$ in the reactor building. Therefore, a purge dryer has been installed to collect heavy water in the air discharged from the reactor building. The purge dryer further reduces the dew point of the air to minimize the amount of heavy water released.

3. The design of the maintenance building ensures control over heavy water releases in heavy water management areas of the maintenance building by moving all the heavy water management systems into an atmospherically separated area of the maintenance building. This area is connected to the maintenance building vapour recover system to ensure that heavy water is collected.

   Also, to prevent downgrading of heavy water and minimize the heavy water upgrading requirement from the maintenance building, the ACR-1000 design has incorporated a double-door airlock at the entrance to the heavy water management area to minimize the migration of light water into dried areas. This improvement ensures that the heavy water collected by the maintenance building vapour recovery system is economical to upgrade, thereby avoiding the possibility of the collected downgraded heavy water being sent to the radioactive liquid waste management system.

4. A BAT assessment was conducted for available processes for treating moderator spent resin produced in the moderator purification system. The moderator spent resin will therefore be dewatered instead of dedeuterated to decrease the overall water requirement and reduce the amount of heavy water that must be upgraded as a result of this process.

   Furthermore, the moderator spent resin slurry function used to transport moderator spent resin to the radioactive solid spent resin handling system storage tanks will be recirculating and will use permanent connections to the moderator purification system to avoid spillage, thereby eliminating the need for frequent slurry water additions. This ensures that the amount of heavy water that must be upgraded as a result of this process is minimized.

## 4.2 Carbon-14

1. Sub-micron filters have been installed downstream of the moderator ion exchange columns in the moderator purification system to capture resin fines. This will prevent resin fines from reaching the reactor core where the fines form carbonate and bicarbonate ions from $^{12}C$. Consequently, saturation of the ion exchange columns with $^{12}C$, which competes for ion exchange sites with $^{14}C$, will be avoided.

2. The moderator cover gas is constantly circulated through the vertical reactivity mechanism thimbles, which pass through the reactor core, to prevent stagnation and build up of gases including $^{14}C$.

3. The annulus gas system design is improved to include an improved compressor, which minimizes air ingress to the circuit and reduces the requirement to purge the annulus gas system frequently.

4. A BAT assessment was conducted for available processes to improve the segregation of moderator spent resin, which contains $^{14}C$, from non-moderator spent resin, which does not contain significant quantities of $^{14}C$. As a result, the moderator spent resin handling functions were designed to segregate the moderator spent resin from the non-moderator spent resin at source and throughout the slurrying and storage process.

## 4.3 Other Airborne

Other airborne radionuclides that are monitored in the ACR-1000 NPP include radioiodine, noble gases (argon, krypton, xenon), and particulates.

1. The use of stainless steel components in the heat transport system decreases corrosion product production, activation, and activity.

2. As described in Section 4.2, the annulus gas system is improved to minimize the ingress of air and, since air contains $^{40}Ar$ impurities, this improvement also minimizes $^{41}Ar$ production.

3. Since the entire fuel handling process will be performed

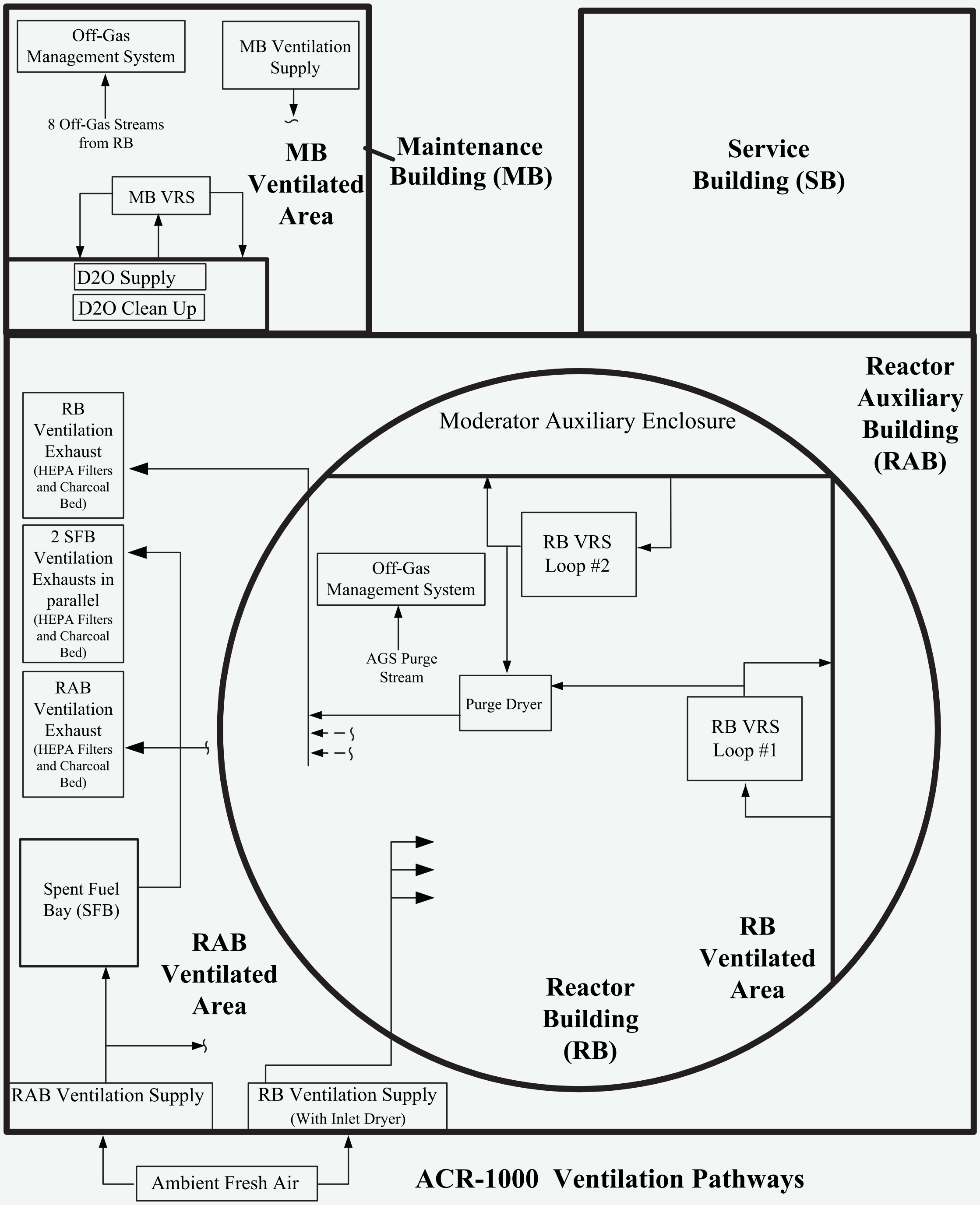



**Figure 1** ACR-1000 Ventilation Pathways

under water, radioiodines and noble gases will not off-gas during handling of depleted fuel and a snout blow-down system will collect water from the fuelling machine snout such that it is not released into the reactor vault.

4. Nitrogen cover gas is used for the fuelling machine to prevent air ingress to the coolant during refuelling operations, thereby lowering the production of $^{41}$Ar.

5. An absorber material for the mechanical zone control system has been selected that minimizes the production of cobalt, antimony, and other airborne particulate.

6. A BAT assessment of available technologies for the off-gas management system was conducted to ensure that $^{41}$Ar, and xenon and krypton were delayed sufficiently for decay. As part of the BAT process, a sub-system of the off-gas management system, the annulus gas system purge delay tanks, were added to the design to address $^{41}$Ar. During the BAT process, it was determined that a significant portion of the $^{41}$Ar produced

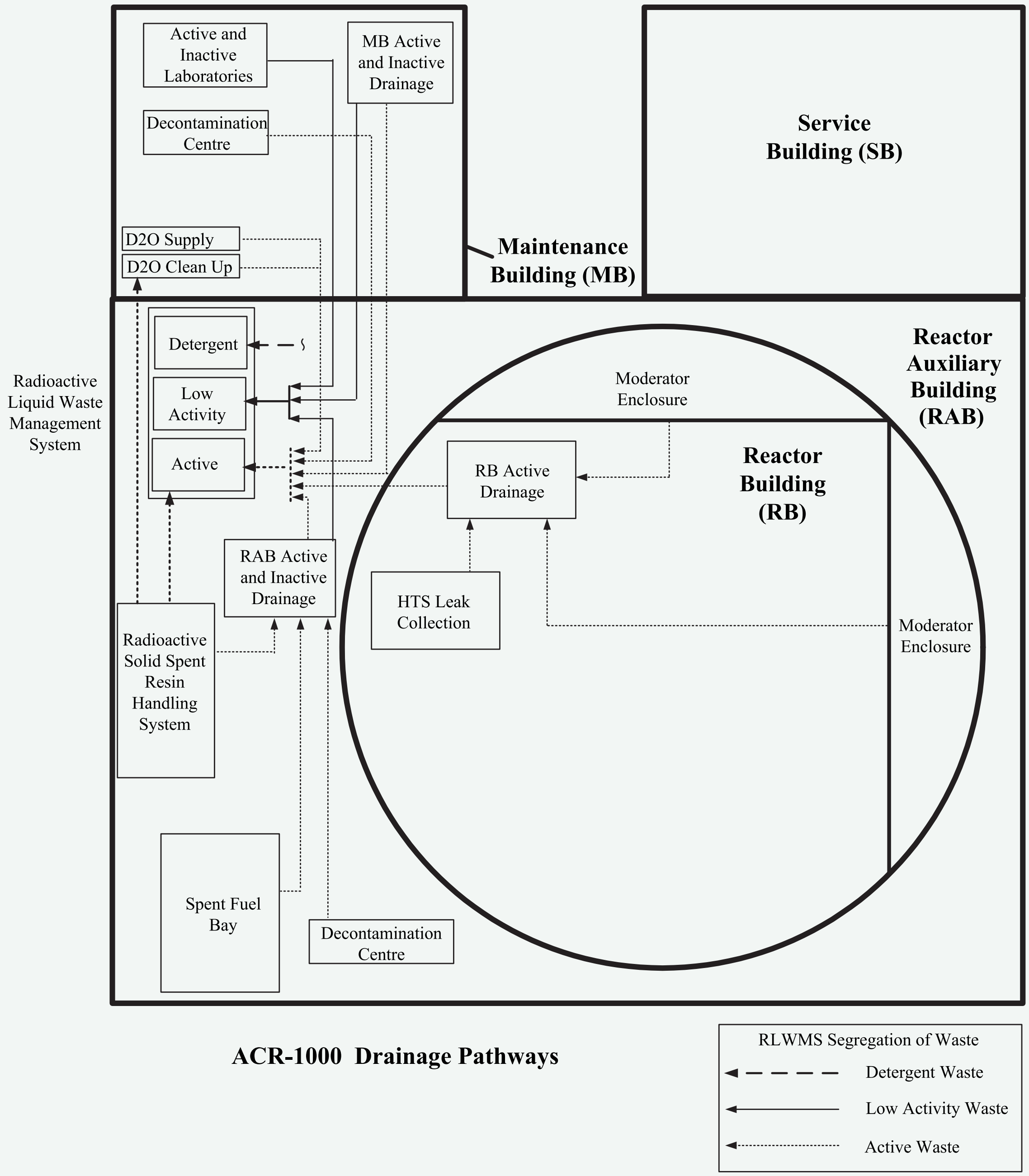



**Figure 2** ACR-1000 Drainage Pathways

in the station originates from the annulus gas system. Since the charcoal adsorber bed in the off-gas management system does not delay $^{41}Ar$ sufficiently for decay, the annulus gas system purge delay tanks use a separate delay mechanism.

### 4.4 Other Waterborne

1. The use of stainless steel components in the heat transport system decreases corrosion product production, activation, and activity.

2. A BAT assessment of available technologies for the radioactive liquid waste management system was conducted. Therefore, a parallel-stream treatment circuit has been incorporated in the radioactive liquid waste management system design to ensure that all water used in the NPP is treated to remove suspended solids, organics and oils, radiological and non-radiological contaminants, and to adjust chemistry.

## 5. ACR-1000 radiation protection

The environmental performance improvements that have been described in this paper also have a direct impact on radiation protection for personnel within the ACR-1000 NPP, and for the public and the environment. During the ACR-1000 design phase, application of the ALARA principle ensured that the design improvement considered was also examined from a radiation protection perspective.

Due to the significant environmental performance improvements inherent in the ACR•1000 design and the environmental performance improvements described in this paper, radiation protection improvements are also inherent in the ACR-1000 design. A component of the BAT assessment methodology and selection process discussed in this paper, for systems that have a direct impact on the environment, was to examine the impact of the design option on radiation protection.

## 6. Conclusions

The ALARA principle has been systematically applied to the design of the ACR-1000 reactor with emphasis on radiation protection for workers, the public, and the environment, and the minimization of radionuclide production and release mechanisms.

The ACR-1000 NPP is capable of achieving excellent environmental performance based on the environmental performance improvements discussed in this paper. A BAT assessment of systems that have a direct impact on environmental protection ensured that the best available techniques have been used in the design of these systems and that industry design and operating experience have been taken into consideration.

## 7. References

[1] CNSC, "Radioactive Releases Data from Canadian Nuclear Generating Stations 1994-2003", INFO-0210, Rev. 12, January 2005.

---

# Russian nuclear icebreaker saves stranded researchers


*The crew of 'North Pole 36' in front of the Yamal (Image: Rosatom)*

At the beginning of September the russian nuclear-powered icebreaker, Yamal, rescued a group of rusian researchers from their base on an ice-floe which had begun to break up.

After 11 months of operation their ice-floe station had drifted about 2500 kilometres across the Arctic Ocean from Vrangelya island north of Russia's far east to close to Greenland. The ice floe had begun to melt and cracking had occurred, signalling that it was at the end of its useful life.

Russia has operated stations like this continuously since the 1930s except for a 12-year period at the end of the Soviet era.

The *Yamal* was dispatched from Murmansk in mid-August to collect the 18 researchers, their dogs and some 150 tons of equipment and then find a suitable ice floe for the next station, probably near Siberia's Taymyr peninsular.

The vessel is powered by two reactors and comes complete with a heated swimming pool, a cinema, two gymnasiums, two saunas and a basketball court as well as guard dogs to protect the crew from polar bears and rocket launchers to break up tough bits of ice.

## 31st Annual Conference of the Canadian Nuclear Society and 34th Annual CNS/CNA Student Conference

### Hilton Bonaventure Hotel, Montréal, Québec, Canada

### 2010 May 24 – May 27

### "Atoms for Power, Health, and the Environment- Les atomes: pour l'énergie, la santé et l'environnement"

# Call for Papers

The 31st Annual Conference of the Canadian Nuclear Society and the 34th Annual CNS/CNA Student Conference will be held in Montréal, Québec, Canada, 2010 May 24 – May 27 at the Hilton Bonaventure Hotel. Note that the conference starts with a Conference reception on Monday evening May 24, Victoria Day.

The central objective of this conference is to provide a forum for exchange of views and ideas and information relating to application and advancement of nuclear science and technology, and nuclear-related issues in general.

- Invited speakers in **Plenary sessions** will address broad industrial and commercial developments in the field.
- Speakers in **Technical sessions** will present papers on their work related to nuclear technology. **This call for papers is to solicit papers in Technical sessions** covering, but not limited to the following **Technical Topics:**

- Reactor Physics, Radiation Physics and Health Physics
- Thermalhydraulics
- Safety and Licensing
- Safety Management and Safety Culture
- Medical Isotope Production and Applications
- Environment and Waste Management
- Process Systems
- Chemistry and Materials
- Instrumentation and Control
- Control Room Operations
- Advanced Reactors and Applications
- Plant Life Management and Refurbishment
- Operation and Maintenance
- Oil Sands Applications

**Important Dates**

- First Call for Papers: 2009 August 31
- Deadline for submission of **full papers:** 2010 January 8
- Deadline for submission of revised final papers: 2010 March 31
- The early registration date: 2010 March 31

**Guidelines for Full Papers**

Papers should present facts that are new and significant, or represent a state-of-the-art review. They should include enough information for a clear presentation of the topic. Proper reference should be made to related published information. The name(s), affiliation(s), and contact information of the author(s) should appear below the title of the paper. A short abstract of 50-100 words must be placed at the beginning of the paper. A length of ~10 pages with an electronic file size of less than 5 MB is suggested for a typical paper.

**Paper Submission Procedure**

Please note that ONLY FULL PAPERS are to be submitted and peer-reviewed for this conference (abstracts or summaries will not be accepted). **Please plan accordingly as 2010 January 8 is fast approaching!** Submissions of full papers should be made electronically, preferably in MS Word format, through the Annual Conference electronic submission system at: **http://www.softconf.com/s08/CNS2010Technical**

To help with planning, authors are kindly asked to log onto the electronic submission system and input the title and main author of their planned paper even before making the full submission.

**Technical Program Co-Chairs**

**Guy Marleau,** Ecole Polytechnique de Montréal
e-mail: **guy.marleau@polymtl.ca** Tel: 514-340-4711 x 4204

**Wei Shen,** Atomic Energy of Canada Limited
e-mail: **cns2010@aecl.ca** Tel: 905-823-9060 x 33335

Information regarding paper template, copyright of papers, publication methods can be found at the conference website: **http://www.cns-snc.ca/conf2010.html**

General inquiries regarding the Conference may be addressed to

**Conference Executive Chair**

**Adriaan Buijs,** McMaster University
e-mail: **buijsa@mcmaster.ca** Tel: 905-525-9140 x 24925

**Denise Rouben,** CNS Office Manager
e-mail: **cns-snc@on.aibn.com** Tel: 416-977-7620

*30th Annual Conference of the Canadian Nuclear Society*
*33rd CNS/CNA Student Conference*

# Should Manitoba Join the Nuclear Club?

by L.A. Simpson[1] and Blair Skinner[2]

*[**Ed. Note.** This paper was presented at the 30th annual conference of the CNS]*

## Abstract

Manitoba hosts the first nuclear community in Western Canada. AECL's Whiteshell Laboratories in Pinawa carried out research on reactor safety, waste management and a number of reactor types including small reactors for powering remote communities. The Whiteshell site is now being decommissioned but will likely remain under CNSC license for the next century. The site is ideal for a new power reactor with its location on a major river, a major transmission corridor that runs through the site, and its proximity to major markets. With the relatively small grid sizes in the Prairie Provinces, it makes sense for the provincial utilities to cooperate in the building of major projects so as not to overwhelm individual utilities with a large power rector. What is needed now is a formal feasibility study to address the economic factors in favour of a nuclear plant compared with the cost of remote hydro dams and expensive transmission costs.

With nuclear expansion now envisioned both east and west of Manitoba it makes sense for the province to become involved. Because of its history and knowledgeable and supportive population Pinawa could readily host a nuclear power plant or any other nuclear operation.

## 1. Manitoba's nuclear history

Pinawa was established in 1963 as a bedroom community for the employees of AECL's second research laboratory, named the Whiteshell Nuclear Research Establishment (WNRE). The Labs were located on the east shore of the Winnipeg River about 100 Km north east of Winnipeg. Pinawa was located 12 Km to the east of the lab at the end of a highway. While the location was fantastic in terms of the natural beauty and recreation potential, it was off the beaten track and visitors rarely came to town unless they had business there. Pinawa's isolation was not a concern since AECL's vision was that the town would grow to a population of 5000 with the anticipated expansion of the lab (one early model of the site showed four reactors, WR1 to WR4). The community actually grew to a population of about 2200 and WNRE did thrive while developing the organic-cooled reactor, studying other reactor concepts and researching reactor safety issues. Because of the early success of the Pickering reactors, AECL's interest in the organic-cooled concept waned, but emerging concerns about spent fuel disposal spawned the Nuclear Waste Management Program (NWMP). The site name was changed to Whiteshell Laboratories. By the mid-nineties, the NWMP and the Reactor Safety Research Program were the main programs at the site, employing over 1000 employees. However there were clouds on the horizon. In 1995, because the nuclear industry was out of favour with the government of the time, AECL was instructed to cut back. A decision was made that AECL would consolidate core R&D (supporting CANDU) at Chalk River and attempt to commercialize the remaining programs, including the NWMP, at Whiteshell. Today there are still over 300 people working at the site, primarily decommissioning the facility. However there are still remnants of the waste management program and the reactor safety research program continuing. An example of this is the RD14 thermal-hydraulic loop which analyses the consequences of a loss of coolant accident in a CANDU Reactor. It is now being used to simulate accidents in ACR1000 geometry.

There is presently no intention of green-fielding the entire site which would be necessary to release it from a CNSC license. The current plan is to decontaminate most buildings and take them down, leave the WR1 reactor in a sealed up state for decades, and reduce the active area footprint to a minimal size. In addition, the high level waste will be stored in canisters on site until such time as a national storage/disposal facility becomes available. The low-level waste will continue to be stored at site in the waste management area in secure facilities.

The past 12 years or so have seen much discussion as to how to use the AECL site [1]. After looking at many non-nuclear options it was clear that the fact that the site was to be under CNSC control for the foreseeable future was an impediment to attracting new businesses. The logical solution was to look abroad in the nuclear industry and see if we could locate new nuclear activities at the site. With the current renaissance in the industry, now would seem to be a good time to move forward. The first place to look is with Manitoba Hydro and to see if a nuclear plant at the Whiteshell site would benefit the province.

## 2. Manitoba Hydro

When we are talking about base-load there are only two possibilities for Manitoba. Coal is not an option because of climate change concerns so that we are left with hydroelectric plants or nuclear plants. Manitoba Hydro currently has a generating capacity of about 5000 MW. About 96% of this is hydro power. There are six small stations on the Winnipeg River generating about 580MW with the bulk of the capacity, 4400MW, generated by the stations on the northern rivers, primarily the Nelson [2].

1. Former Mayor, Pinawa, Manitoba, Canada
2. Mayor, Pinawa, Manitoba

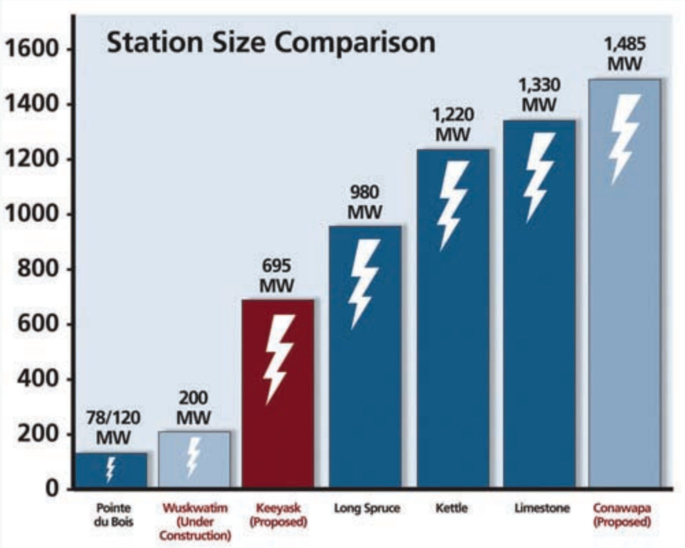



**Figure 1.** Some present and planned hydro electric stations on Manitoba's grid [2].

To bring the northern power to market requires high voltage DC transmission lines over distances of more than 700Km. Table 1 shows the current and projected capacities and costs for the northern plants.

Costs are very sensitive to the date built and the number for Conawapa is an estimate that includes the transmission line cost and is probably low. Coupled with this is an additional transmission cost of about 400M$ to bring the line down the west side of Lake Winnipeg rather that the shorter east side route. This reflects the current Premier's desire to have the east side recognized as a United Nation's World Heritage Site and is a highly controversial issue at present.

As might be expected with their very strong commitment to Hydro Power, Manitoba Hydro has not shown a lot of interest in building an infrastructure of nuclear expertise. They have however indicated a willingness to buy and market the power if it's produced by a private vendor who will build and operate the station. There appears to be a willingness from AECL to examine such an arrangement. Bruce Power also seems to be interested in such an arrangement in Saskatchewan. The time seems ripe for a feasibility study in Manitoba that will examine the economics of such an arrangement.

## 3. Advantages of the Whiteshell site

### 3.1 Nuclear license

The Whiteshell site has been licensed for nuclear operations by the Canadian Nuclear Safety Commission and its predecessors since 1964. This included a license for the WR1 research reactor which operated at the site until 1980 when it was shutdown and defueled due to a lack of funds to continue development of the organic cooled reactor. The site now holds a decommissioning license renewable in ten years and present plans see the continued storage of some nuclear waste and the WR1 building indefinitely [3]. Given the fact that the site will continue to be under nuclear license, it makes most sense to locate new nuclear facilities there. Any new activity will naturally require a new license but this will be more easily obtained for a site that has held previous licenses. AECL has done extensive site characterization and collection of baseline environmental data, which would facilitate a successful application for a Site Preparation License and nuclear plant Construction License. The site has an ample source of cooling water supplied by the Winnipeg River.

During the initial stages of AECL's shutting down, many failed attempts were made to attract non-nuclear businesses to the site but the proximity to licensed facilities was a problem. While the federal government through AECL remains owner of the property, they are prepared to negotiate for new nuclear businesses to locate at the site, including a new nuclear power plant.

### 3.2 Winnipeg River

The WL site is located adjacent to the Winnipeg River, which will supply plenty of cooling water for a nuclear reactor. The flow of the river is relatively stable as it is controlled by 6 Manitoba Hydro Electricity Generating Stations, 3 upstream and 3 downstream of the WL site. The average flow rate upstream at the Slave Falls Generating Station is 860m3/s. The once through flow rates for an AECL – Enhanced CANDU 6 is 43m3/s and an ACR 1000 is 67m3/s [4]. These are the upper limits to the required flow rates and normally the impact on the River flow would be less than the rates quoted. The Winnipeg River will supply adequate cooling for a nuclear reactor built at the WL site.

### 3.3 Transmission corridor

A Manitoba Hydro High voltage transmission line passes right through the site bringing power from the Winnipeg River dams into Winnipeg. Thus a corridor already exists for upgrading to handle a line from a nuclear plant. A new converter station (Riel) is planned for a location just north-east of Winnipeg to enhance the reliability of the Manitoba Grid and for power exports to the USA. This is less than 100Km from the Whiteshell Site and would be an ideal location for directing exports.

Nuclear generated electricity is not dependent on the wind or the amount of precipitation. It would therefore add to the solid foundation and robustness of Manitoba Hydro's ability to produce electricity during all seasons and weather conditions. For example low water levels three years ago prevented Hydro from operating their stations at capacity and the normally profitable company lost $300M. Long unguarded transmission lines are also susceptible to severe weather and saboteurs and total dependence by the province on these transmission lines is a concern. The diversity offered by a nuclear plant on the grid would provide security of supply as Gentilly-2 did for Montreal during the ice storm in 1998.

### 3.4 Nuclear friendly population in Eastman

Eastern Manitoba has been a major player in the nuclear industry since 1963. At its peak, the Whiteshell Lab employed

**Table 1.** History of Manitoba's hydro construction program with original cost. [2]

| STATION | CAPACITY (MW) | DATE COMPLETED | COST M$ | COST MW ($) | RIVER |
|---|---|---|---|---|---|
| Kelsey | 223 | 1961 | 50 | $ 0.22 | Nelson |
| Grand Rapids | 479 | 1968 | 117 | $ 0.24 | Saskatchewan |
| Kettle | 1220 | 1974 | 240 | $ 0.20 | Nelson |
| Long Spruce | 1010 | 1979 | 508 | $ 0.50 | Nelson |
| Limestone | 1340 | 1990 | 1430 | $1.07 | Nelson |
| Conawapa (Prop) | 1485 | Future | 7200 | $5.14 | Nelson |
| Wuskwuatim | 200 | Under Construction | 1600 (Est.) | $8.0 | Burntwood |

**Table 2:** Comparison of Capital Costs

| FACTORS AFFECTING CAPITAL COST | HYDRO | NUCLEAR |
|---|---|---|
| Construction Cost | Higher | Lower |
| Operating Cost | Lower | Higher |
| Transmission Cost | Higher | Lower |
| Footprint | Kilometers | Meters |
| Land Settlement Issues | High | Low |
| Sensitivity To Drought Conditions | High | Low |
| Permanent Job Creation | Low | High |
| Construction Time (After Construction License) | 8-10 Years | 4 Years |

over 1000 scientists, engineers and support staff with a budget of 85M$, mostly spent in the region. This was a significant economic driver for the province. There are now about 300 AECL employees at the site doing mainly decommissioning work but also work on waste management and reactor safety experiments. This would provide an excellent nucleus on which to build new facilities, not just a power plant, but any part of the fuel cycle. The communities of the North Eastman region of the province, particularly Pinawa and Lac du Bonnet, are already familiar with the nuclear industry, and the economic benefits it provides. In addition, because of the large ex-AECL retirement community, there is still considerable nuclear expertise in the region to support the development of a nuclear power facility.

The economic benefit of nuclear generating capacity is substantial. The construction project would be on the order of 3-10 billion dollars depending on the size and type and number of reactors constructed and the ongoing operations would provide over 500 full-time well paid jobs for 60 years. This would have a very positive impact on the communities of the Eastern Region of Manitoba, on Winnipeg, and on the Province of Manitoba. In addition to revenues generated from the sale of the electricity generated by the facility, the Province of Manitoba would realize a return on investment from Personal Income Taxes of the employees, Payroll Taxes from the organization, and Retail Sales Tax from the operation.

## 3.5 Cost comparison

A cost comparison is not simple as it depends on a lot of factors as shown in Table 1. We believe that it is necessary to use a $/MW basis as total capacities will probably differ when comparing specific station types. However it is our feeling that nuclear power delivered at Pinawa could show a favourable cost advantage to that from the northern rivers and that is why we are inviting a feasibility study that takes in to account all the factors in Table 2. It is important to note that cost estimates for the production of electricity from a nuclear facility include decommissioning costs and the cost for the permanent disposal of the used nuclear fuel.

## 4.0 Safety concerns

There is a broad spectrum of public opinion on nuclear power. By and large the general population favours it by a slim majority with the most favourable views found close to areas where some aspect of the industry is operating. This reflects a higher level of knowledge about things nuclear and comfort in the safety culture that exists. The two most frequently stated concerns of the politicians are that "we don't know what to do with the waste" and "the plant emissions of radioactivity are dangerous". The last concern evolves from the statement by the more extreme elements that "there is no safe level of radioactivity". The CNSC determines the levels of radiation that the public can be exposed to and comes up with a value at the plant boundary of one milliseivert (mSv), roughly 1/3 of the average dose received by people from natural background and medical sources [5]. Plant operators actually target a much lower value of 0.01 mSv at the plant boundary. At these levels it is impossible to measure any effect on the local population and, in fact, for exposures up to

100mSv it has been impossible to detect any increase in cancer rates in the general population [6].

There are over 400 operating nuclear power stations in the world including 20 in Canada. Nuclear power plants worldwide have an excellent safety record and are subject to very stringent regulation. In Canada, the Canadian Nuclear Safety Commission ensures that nuclear facilities are designed and operated at the highest standards. Generally, the highest support for nuclear power plants is found in the communities closest to these plants.

There is regulation on all nuclear reactors although the details differ by country. In Russia, since the Chernobyl event 20 years ago, regulation has been brought up to western standards. Even by the original Russian rules, that reactor was carrying out an experiment under conditions for which it was not licensed and with all the safety systems shut off. Even with the explosion a proper containment building would have gone a long way to mitigating the consequences. Today the media is rife with statements of casualties from that event but as yet other than about 50 deaths of the reactor operators who received huge doses of radiation, and some cases of thyroid cancer which is usually treatable, the World Health Organization is unable to detect any increases of cancer deaths in the region. As a result of that accident, there has been strong collaboration among the OECD countries and Russia who have invested astronomical sums of money on severe accident research, so that today the severe accident probability that was originally very low has been reduced by at least another order of magnitude.

On the waste management issue, the federal government has formally chosen the Nuclear Waste Management Organization's Adaptive Phased Management method [6] of deep geological disposal of high-level waste, based primarily on research carried out at Whiteshell. The Nuclear Waste Management Organization is now in the process of developing criteria for site selection. A portion of revenues from the generation of nuclear power is segregated for the eventual construction and management of a disposal facility. When the repository is built the fuel will be safely stored in a retrievable way. This will ensure that it will still be available if the industry moves toward reprocessing spent fuel and recycling it in reactors. Many in the industry argue that burying spent fuel after one pass through a reactor is wasteful and we lose over 90% of the energy remaining in the fuel. By recycling the fuel, the long lived actinides are destroyed and the ultimate waste volumes are greatly reduced. Sixty years from now the decisions whether or not to recycle will have been made and permanent burial can then occur, either of the original spent fuel, or the much lower volumes of waste from the recycling process.

So basically, the politician's views are more attune to not raising the issue of nuclear power with their constituents than based on facts.

## 5.0 Interprovincial cooperation

In Canada it has become common to design nuclear plants of high capacity (1000MW+) to achieve economy of scale. This is certainly the reasoning behind the ACR 1000 and other vendors are offering similar sizes for domestic base-load. For utilities in Ontario this is not a problem as the Ontario grid delivers more than 28,000MW. However Manitoba's grid delivers up to about 5000MW and the sudden addition of 1200MW would have a large impact on the total. However Manitoba Hydro's proposed hydro stations are of similar capacity, and they plan to market the sudden excess of capacity in the USA and neighbouring provinces. Both Saskatchewan and Alberta are considering building nuclear stations and their generating capacities are 3,000 and 12,000 MW respectively. Both provinces would like to replace fossil plants with carbon free sources. Saskatchewan also is interested in supplying the US market. When the three provinces and the US market is looked at as a whole and with improvement in interprovincial connections, there would be much more flexibility in absorbing a nuclear station.

## 6.0 Activities of the nuclear committee of council

Since the municipal elections in 1998, the Council of the Local Government District of Pinawa has been aggressively focussed on economic development including the development of other activities at the WL site. Over the last 4 years, the Council has been steadily building support for developing the WL site for nuclear electricity generation. The first formal step was taken when a Resolution was tabled at the November, 2006 annual convention of the Association of Manitoba Municipalities. The resolution read:

> *"THEREFORE BE IT RESOLVED THAT the AMM lobby Manitoba Hydro to give serious consideration to a nuclear power station in its future plans for base-load generation, in particular maintaining a detailed cost comparison between nuclear and hydro and recognizing the advantages to the economy of Manitoba of having the long-term, high paying jobs for the life of the plant;*
>
> *AND BE IT FURTHER RESOLVED that Manitoba Hydro recognize the suitability of Pinawa and the site of Whiteshell Laboratories for a nuclear plant with its proximity to cooling water, an existing transmission corridor, the fact that the site will continue to be under nuclear license for at least a century and the familiarity and comfort of the people in the region with the industry."*

Perhaps surprisingly, no one chose to speak against the resolution during the debate and the resolution passed very easily with very few opposed. Since the delegates represent all municipalities in the province, one could conclude that the "grass roots" opposition to nuclear was not as great as many have anticipated.

In 2007, the Nuclear Option committee of the Pinawa Community Development Corporation was formed to pursue this initiative. The Mayor, one Councillor and two other Directors of the PCDC board are on the committee. We have also received a formal letter of support from the Nuclear Workers Council and a local representative sits on the committee. AECL has agreed to participate as a resource. The Town and Rural Municipality of Lac du Bonnet have both agreed to participate in the process. Recently, Mayor Skinner updated the Eastern Manitoba Mayors and Reeves on our activity, and again, no one seems to have any deep concerns over the initiative. People seem to recognize that the nuclear industry has operated for many decades in Canada, with little impact on safety or the environment. Consequently, the jobs created, the economic impact, the need to fight global warming, all seem to outweigh the concerns about safety and nuclear waste disposal.

We have had a presence at the CNA Winter meetings where we also met with other members of the Canadian Association of Nuclear Host Communities. We recently attended a conference in Regina focussed on nuclear energy [8] and are here at this conference. These meetings provide valuable information about the current status of the nuclear industry and excellent networking opportunities to build support of our initiative to get a feasibility study for Manitoba.

Twice in 2008, we met with the senior officials of AECL, Manitoba Hydro and the Minister Responsible for Manitoba Hydro to stimulate Manitoba's interest in the nuclear option. The provincial Minister indicated that it was an idea that the provincial government could not immediately embrace since Manitoban's had not had an opportunity to have a dialogue on the subject. MB Hydro indicated that they have several major hydro projects in various stages and that all of their resources were focussed on those projects. Nuclear would eventually become part of the mix but would be after all the potential hydro capacity was developed. The province agreed that nuclear was a viable option should development of hydro in the north be delayed to the point where Manitoba could not deliver on export contracts. While these reactions may seem negative, recognize that the government is not going to rush into nuclear power without strong political and economic support. This is why our first goal is to get the feasibility study which should provide this information. While Manitoba Hydro is fully involved in dam building they have indicated they would consider including in their grid, a station built and operated by a private organization.

The issue of nuclear power in Pinawa has been raised by the newspaper media and CBC radio in Winnipeg twice over the past 18 months. Both times, it was expected that a significant opposition voice would be heard, but in fact, the response has been generally positive. There is a local resident who is opposed to nuclear, but his only argument is that it is not needed by Manitoba and it should be built where the power is needed. This argument has minimal merit, however, since Manitoba along with the rest of Canada produces many commodities that are exported. Electricity is among them. Indeed, the Province of Manitoba has recently concluded agreements to sell power to Minnesota and Wisconsin. It is reasonable to assume that these markets are going to expand. After all, it does not make sense to burn coal, oil, or gas to power electric cars. Recently, there have been newspaper reports of discussions between Sask Power and Manitoba Hydro on strengthening the grid between the two provinces. This includes the possibility of using federal infrastructure funding for improving this important asset. This would greatly increase the potential for export of electricity to the West.

We believe that the time has arrived to have the public debate on nuclear generated power in Manitoba. We are supportive of development of all potential hydro resources and wind power but it should be in the context of a thorough alternatives analysis. The nuclear option would provide important diversification for the Manitoba's domestic and export electricity needs and reduce the impact of weather on supply. The economic benefits far outweigh the concerns over safety and the disposal of spent nuclear fuel. The incremental environmental impact of a nuclear project would be minimal as the footprint is already well established and is adequate and suitable for nuclear reactors. To further this argument, we are currently working on developing support for a feasibility study. This would provide all of the information required to have an informed debate on the nuclear option.

Should Manitoba Consider Nuclear? We have the first two ingredients required for a nuclear power station: a suitable site and a willing host community. Pinawa, Manitoba and Western Canada should capitalize on this important asset.

## 7.0 Summary

We have an ideal site, a willing community, but no immediate need for an additional power plant if Manitoba goes ahead with its plans for more northern hydro stations and more long transmission lines. However, if an economic and social argument can be made to build a nuclear plant in the south then perhaps some long range plans should be reconsidered. Also the future projects for transportation including electric and hydrogen powered vehicles could cause a substantial increase in electrical power in the next decade or two. West of Manitoba there is clearly a need for more energy to replace fossil plants and to supply the oil sands projects with clean energy that saves precious natural gas. It makes sense for more collaboration between the three prairie provinces, with their small grids, to improve transmission interconnections and plan the acquisition of new facilities together. Hopefully, this paper will serve to increase awareness of each other and of our nuclear site in Pinawa, where we have held nuclear licenses for nearly 50 years and would be a willing recipient of a new nuclear facility. Hopefully too, it may serve to help allay fears of those opposed to nuclear power.

## 8.0 References


[1] L.A. Simpson, "Pinawa, twelve years later", Canadian Nuclear Society Bulletin, Vol. 29, No. 3, 2008, pp 9-14.

[2] Manitoba Hydro Website, "www.hydro.mb.ca/projects".

[3] Renewal (2008) of the Whiteshell Site Decommissioning Licence -Information Presented for the One Day CNSC Public Hearing, November 5, 2008.

[4] R. Oberth, Atomic Energy of Canada Ltd., Private communication, May 2009

[5] Government of Canada, "Nuclear Safety and Control Act", Ottawa, May 2000.

[6] Committee on Medical Aspects of Radiation in the Environment (COMARE), Twelfth Report, Health Protection Agency, UK, 2007.

[7] Nuclear Waste Management Organization, Final Study, "Choosing a Way Forward", Toronto, November 2005

[8] "The nuclear option in a carbon constrained world", Saskatchewan Environmental Industries and Managers Association, and Manitoba Environmental Industries Association, Regina, Canada, 2009 March 16-17.

# Nuclear Experts

Kinectrics offers unique testing and assessment capabilities to help utilities and suppliers make and validate critical decisions for both existing nuclear plant operations and, new station design / build projects. Kinectrics delivers proven solutions that provide reliable cost-effective support throughout the entire component and plant life cycle.

## Life Cycle Management Solutions

NEW PLANT DESIGN AND CONSTRUCTION SUPPORT
- Advanced Reactor Equipment Qualification & Type Testing
- Seismic Qualification & Testing
- EMI / RFI Testing
- Non-Destructive Evaluation (NDE)
- Environmental Testing & Studies

OPERATING PLANT ISSUES SUPPORT

**Nuclear Safety Margins & Performance Demonstration**
- Equipment Qualification Testing & Studies
- Operability Simulations & Testing
- Probability Risk Assessment Analysis
- Licensing & Regulatory Affairs Support

**Sustaining or Improving Equipment Reliability**
- Field NDE (VT to Phased Array UT methods)
- Electrical Equipment & Cable Condition Assessment
- Mechanical Testing
- Rotating Machine Monitoring & Condition Assessment
- Root Cause Failure Analysis & Forensic Evaluation
- Concrete Structure Assessment, Repair & Rehabilitation
- Obsolescence Management & Reverse Engineering

**Enhanced Radiation & Environmental Protection**
- Tritium Management
- Radioactive Materials Characterization
- Fish Protection / 316 (a)&(b) Solutions
- Environmental Assessment & Thermal Studies

**Product Quality & Performance Validation**
- Commercial Grade Dedication (CGD)
- Seismic Qualification
- EMI / RFI Testing

**Advanced Services by Kinectrics Companies**
- Field Inspection – CGSB & ASNT NDT & Level III Services by **Axiom NDT Corp.**
- Nuclear Regulatory, Safety, Licensing, Health & Environmental Services by **Candesco Corporation**

KINECTRICS

## Nuclear Knowledge

www.kinectrics.com

# GENERAL news

(Selected by Fred Boyd from open sources)

## AECL webcasts NRU progress

Atomic Energy of Canada Limited has turned to the web to provide updates on the repairs to the NRU reactor.

Video presentations have been posted of Hugh MacDiarmid, President and CEO outlining the plan and of David Cox, NRU Restart Project Director, describing how the repairs to the calandria will be done.

In the video MacDiarmid promises that the repairs will be completed in the first quarter of 2010.

Cox describes the challenge of inspecting the inside of the calandria and the special tools that were developed to carryout the task. He also describes the "weld build-up" process that will be used to strengthen the corroded parts of the calandria shell.

## AECL and CNSC sign protocol for NRU restart

On August 14, 2009, Atomic Energy of Canada Limited and the Canadian Nuclear Safety Commission signed a joint Protocol for the NRU Restart Licensing Activities.

The purpose of the Protocol is to establish the administrative framework, milestones and service standards for the licensing activities in relation to the restart of the NRU reactor after repair of the reactor vessel, including the submission by AECL of the technical information to support an application for Commission approval to re-load fuel in the reactor and the CNSC review of this technical information.

The Protocol covers the following phases of the work to return the NRU reactor to service:

- assessing the condition of the NRU reactor vessel
- repairing the rector vessel (including the post-repair inspection)
- re-establishing the reactor's fitness for service (including mitigation of the degradation mechanism).

It states that the milestones have been established on the basis of a number of assumptions, some of which relate to activities of participants to the project that are not signatories to the Protocol. It further cautions that if events unfold in a manner that is different from what has been assumed the milestones will have to be revised.

## CNSC hearing on Port Hope cleanup project

The project to deal with the historic radioactive waste in and around Port Hope, Ontario finally reached the stage of an official hearing before the Canadian Nuclear Safety Commission on August 26, 2009, after more than two decades of studies.


The hearing was held in Port Hope and attracted 99 intervenors, 45 of whom made oral presentations. CNSC released the transcript of the hearing a week later and it contained over 600 pages.

The basic problem concerns radioactive material left in various parts of the town back in the 1930s by the company Eldorado Mining and Refining Limited which at that time operated the Port Hope facility to extract radium from uranium mined in the Northwest Territories

That company was taken over by the federal government in 1944 to extract uranium. For that reason the federal government has assumed the responsibility for the cleanup. In 1998 Eldorado was dissolved and Cameco was formed. Cameco operates the Port Hope conversion facility for the production of UO2 and UF6.

During the 1970s contaminated soil and waste was discovered on private properties and elevated radon levels were detected inside some homes and schools. To address that problem a Federal – Provincial Taskforce on Radioactivity was created by the Atomic Energy Control Board (predecessor of the CNSC). More than 400 properties were remediated and approximately 100,00 cubic metres of contaminated soil were shipped to the Chalk River Laboratories of Atomic Energy of Canada Limited. In 1982 AECL, on behalf of the federal government, set up a low-level radioactive waste management office in Port Hope.

For the next two decades efforts proceeded to find an acceptable, long-term, solution to the historic waste problem.

In 2001 the Port Hope Initiative project was launched with the signing of an agreement by the Minister of Natural Resources and representatives of the municipalities in which the waste is situated. That agreement commits the Government of Canada to perform all of the work required to deal with the waste. The project has three stages: Phase 1, begun in 2001, to obtain the necessary regulatory approvals; Phase 2, to begin in 2011, is to achieve the remediation objectives and the construction of new long-term waste facilities; Phase 3, beginning in 2018 deals with the monitoring and maintenance of the new facilities as long as necessary.

As the agent of the federal government AECL is seeking a 10-year waste nuclear substance licence for the Port Hope Project.

## WANO Leaders Gather at Darlington Nuclear

Leaders from the World Association of Nuclear Operators (WANO) gathered in July at the Darlington Nuclear Station to tour and learn more about Darlington's operations during WANO's annual Site Vice Presidents and Plant Managers working meeting.

"This is the first time WANO has held this meeting at a Canadian station, which is a tremendous honour for Darlington and OPG," said Stu Seedhouse, Senior Vice President, Darlington Nuclear. Darlington was selected as a result of the stations strong performance in 2008.

The theme of the meeting – Achieving Sustainable Performance Improvement – provided Ontario Power Generation staff the opportunity to presents the OPG Accountability Model, which focuses on addressing human performance behaviours and fostering an environment of trust, alignment and teamwork.

Dave Farr, Director of WANO Atlanta Centre, and his international counterparts commented favourably on OPG's welcoming hospitality, and offered high praise for the impressive performance of Darlington Nuclear and the obvious pride demonstrated by its staff.

*Stu Seedhouse, Senior Vice President, Darlington Nuclear (centre) is joined by WANO directors Ronald Crawford and Dave Farr.*

## New president of AREVA Canada

**Roger Alexander** has been appointed to the role of President and CEO of AREVA Canada Inc. with overall responsibility for its Canadian operations.

He succeeds Armand Laferrère who served as CEO since 2006. Prior to this appointment, he served as Vice President of AREVA NP Canada Ltd. and was responsible for leading AREVA's growing Canadian Nuclear business. In his new role, Roger is responsible for the strategic leadership of AREVA Canada's nuclear plants and services, uranium mining, and transmission and distribution businesses.

A Canadian, Roger brings more than 25 years of varied experience to the position. Prior to joining AREVA, Roger held senior leadership positions at Siemens Canada where he was responsible for various business units and all manufacturing and engineering related matters. He is a graduate of Ryerson Polytechnic University with a diploma in Electrical Technology and is a Certified Engineering Technologist (Industrial Control). Roger holds a Master's of Business Administration from the University of Western Ontario's Richard Ivey School of Business.

## AECL posts summary of letter from former MAPLE project leader

At the end of July 2009, Atomic Energy of Canada Limited issued a press release and posted on its website a summary of a letter to the National Post newspaper by Jean-Pierre Labrie, currently Manager of Reactor Physics and Systems Behaviour, Office of Chief Engineer, AECL. Labrie was the director of the MAPLE project for the first seven years.

In the summary Labrie is quoted as stating that:

"... there are significant technical and regulatory hurdles that require ... at least five to six years intensive research and analysis before we can even consider bringing the MAPLE reactors on line".

"The main hurdle to completing the reactors was, and remains, resolving a power coefficient of reactivity PCR) issue."

"Extensive scientific analysis, consultations with the Korea Atomic Energy Research Institute and tests conducted between June 2003 and May 2008 could not resolve the PCR issue."

"Resurrecting the MAPLE project is not a quick fix to today's global isotope issue."

(When the MAPLE project was terminated in May 2008 its president Hugh MacDiarmid essentially said the same words. The publishing of a summary of Labrie's letter indicates that AECL senior management accept his viewpoint.)

## MDS Inc to concentrate on MDS Nordion

On September 2, 2009 MDS Inc. announced it will sell off two of its three business units, MDS Analytical Technologies and MDS Pharma Services. This will leave MDS with just one business unit, MDS Nordion, which has been operating as a separate business.

MDS Nordion has been the strongest part of the MDS structure despite the problems of the prolonged shutdown of NRU.

However, the diagnostic radioisotope activity concentrating on Molybdenum 99 is only about 40% of Nordion's business. It also builds sterilization facilities using Cobalt 60 obtained from Canadian power reactors and produces radio-therapeutic products.

Meanwhile MDS Nordion has been urging the government and Atomic Energy of Canada Limited to restart the MAPLE project. It has submitted an "Expression of Interest" to the Expert Review Panel on Medical Isotopes set up by the Minister of Natural Resources in the spring.

## AECL appoints new Chief Technology Officer

At the end of July 2009, Atomic Energy of Canada Limited announced the appointment of Dr. Anthony (Tony) De Vuono as Senior Vice-President and Chief Technology Officer.

Dr. De Vuono's primary responsibility will be the development of AECL technology, ensuring that AECL products have superior features with competitive costs while fully meeting all applicable safety and licensing requirements.

The position is one of the three senior vice-president positions in AECL's CANDU Reactor Division. Dr. De Vuono will work closely with the senior vice-presidents of Marketing & Business Development (Ala Alizadeh) and Operations (Ron Cullen) to create a collaborative team that fully supports the functional alignment of developing, selling and delivering AECL's nuclear products to meet customer needs.

Dr. De Vuono received a bachelor of science in Mechanical Engineering as well as a master's degree and a doctorate in nuclear engineering from Ohio State University. He served most recently as Vice-President and Chief Technology Officer at Modine Manufacturing Company in Wisconsin. Previously, he was Staff Scientist at the Lawrence Berkeley National Laboratory (University of California at Berkeley); and Principal Research Scientist at Battelle Memorial Institute in Ohio. In these positions, he was accountable for major global research programs in long-term product development cycles.

As a professor at both Ohio State University and University of Illinois, he taught nuclear engineering, from introductory to advanced courses in areas such as nuclear heat transfer. Dr. De Vuono holds six U.S. patents and has authored numerous publications. He began his career in the U.S. Navy Nuclear Power Program.

## CNSC completes Phase 2 of ACR 1000

Last December the Canadian Nuclear Safety Commission reported that it had completed Phase 1 of a Pre-Project Review of the design of the Advanced CANDU Reactor – ACR-1000 of Atomic Energy of Canada Limited. That review determined that the design intent was compliant with CNSC requirements and expectations.

On August 31, the CNSC published its conclusions from its Phase 2 review, which involved identification of fundamental barriers to licensing. The CNSC reported that, based on the Phase 2 review, CNSC staff concluded that there are no fundamental barriers to licensing the ACR-1000 design in Canada. It cautioned that this decision is subject to the successful completion of AECL's planned activities, in particular those related to research and development.

The Phase 2 review focussed on 17 review area, 16 of which had been initially reviewed in Phase 1. The additional focus was the ACR 1000 research and development program.

For each of the design review focus areas CNSC staff assessed the submitted documentation against:

- The Nuclear Safety and Control Act and Regulations
- CNSC regulatory documents, especially RD 337 "Design of New Nuclear Power Plants"
- CSA standards and codes and international standards.

CNSC stated that the Phase 2 review permitted CNSC staff to gain a more complete understanding of the ACR-1000 design while providing AECL further insight into the application of RD 337.

## Further studies of climate warming

In its September 4, 2009 issue, the Journal "Science" includes a report on observations of temperature in "recent" times (1,000 years). Following is the abstract.

*The climate and environment of the Arctic have changed drastically over the short course of modern observation.* ***Kaufman et al.*** *synthesized 2000 years of proxy data from lakes above 60˚ N latitude with complementary ice core and tree ring records, to create a paleoclimate reconstruction for the Arctic with a 10-year resolution. A gradual cooling trend at the start of the record had reversed by the beginning of the 20th century, when temperatures began to increase rapidly. The long-term cooling of the Arctic is consistent with a reduction in summer solar insolation caused by changes in Earth's orbit, while the rapid and large warming of the past century is consistent with the human-caused warming.*

## Bruce Power celebrates safety record

At the end of August 2009 Bruce Power celebrated 15 million hours worked without an acute Lost-Time injury.

Those 15 million hours equal more than two years worked by over 2300 people on a site that is bustling with activity.

Murray Elston, Vice President of Corporate Affairs commented, "This achievement is particularly noteworthy when you consider our site is the most active in North America and over the past several years has recruited more than 1,500 new employees."

To mark the occasion Bruce Power donated $15,000 to the United Way of Bruce-Gray for a program that provides backpacks and school supplies to children in need.

Bruce Power and its employees have a record of supporting the community. The previous week the company's annual charity golf tournament provided $100,000for hospital foundations in the communities of Kincardine and Saugeen Shores.

## New IAEA Director General confirmed

On Septembeer 14, 2009, the 53rd IAEA General Conference confirmed the appointment of Mr. **Yukiya Amano** of Japan, a Japanese career diplomat, as the next IAEA Director General. Mr. Amano assumes office on 1 December 2009, succeeding Dr. Mohamed ElBaradei to the Agency´s top post. His appointment is for a term of 4 years - until November 2013.

Mr. Amano was formerly the Permanent Representative and Ambassador Extraordinary and Plenipotentiary of Japan to International Organizations in Vienna and Governor on the IAEA Board of Governors. On 2 July 2009, Mr. Amano was selected by the IAEA Board of Governors to succeed Dr. ElBaradei.

Ambassador Amano, 62, has extensive experience in disarmament, non-proliferation and nuclear energy policy and has been involved in the negotiation of major international instruments. He has held increasingly senior positions in the Japanese Foreign Ministry, notably as Director of the Science Division, Director of the Nuclear Energy Division and Deputy Director General for Arms Control and Scientific Affairs.

Amano will be the fifth Director General of the IAEA in its 52-year history. He will succeed Mohamed ElBaradei, who was first appointed to the office effective December 1997, and reappointed in 2001 and 2005. Other former IAEA Director Generals were Hans Blix, from 1981 to 1997; Sigvard Eklund, from 1961 to 1981; and Sterling Cole, from 1957 to 1961.

In a statement to delegates of the *Conference*, Mr. Amano described his appointment as coming at a period of change in the global situation surrounding the IAEA. These changes include increasing risks of nuclear proliferation and nuclar terrorism, and concerns about energy demand, climate change, food security, water resources, human health and the economic development. He stressed that the IAEA can maximize its contribution in addressing these global issues by pursuing its dual-objective: ensuring the non-proliferation of nuclear weapons on one hand and promoting the peaceful uses of nuclear technology on the other.

## Nuclear regulators move towards standardization

At a meeting in Paris in early September 2009 represetnatives of nuclear regulatory organizations around the world met with representatives of vendors. operators and standards organizations to discuss moving forward on a program for greater standarization of regulatory practices.

In 2007 nuclear regulators of ten countries: Canada, China, Finland, France, Japan, Korea, Russia, South Africa, the United Kingdom and the United States created the Multinational Design Evaluation Programme (MDEP). The aim was the development of innovative approaches for the regulatory review of new reactor designs and the pooling of resources and knowledge. Through this enhanced co-operation, regulators hope to improve the efficiency and effectiveness of the design review process and increase convergence of regulatory practices.

Having progressed significantly in their objectives, the MDEP members felt that it was timely to organise a formal exchange with national regulators from other countries, industry representatives and standards development organisations. The MDEP conference was held on 10-11 September and brought together more than 170 attendees from 23 countries and 10 international organisations.

The regulators from countries with a limited number of reactors or with civil nuclear plans were eager to benefit from the experience of nuclear safety authorities reviewing new reactor types.

Mr. Andre-Claude Lacoste, Chairman of the French Nuclear Safety Authority and also of the MDEP Policy Group, commented that the MDEP is a key program for new build activities. "This is a long-term process", he said, "that will produce interim results." He expressed his pleasure that the conference brought together a large representation of vendors, operators, code organisations and regulators.

## New head of WANO

The World Association of Nuclear Operators (WANO) appointed George Felgate to succeed Luc Mampaey as Managing Director as of September 1, 2009.

Felgate was formerly Vice President of Plant Operations at the Institute of Nuclear Operations (INPO) in the USA. He joined INPO in 1982, was elected Vice President in 1996, and has served as Vice President of the Analysis and Administration Divisions, Director of Personnel, and Manager of Operations, Training Resources, and Emergency Preparedness Departments.

Mr Felgate takes up his new position on 1 September 2009 and will be located at the WANO Coordinating Centre in London.

WANO is an international organisation with a single aim - to promote the highest levels of safety and reliability at nuclear power plants around the world. Membership includes the operating companies of 447 nuclear plants in over 30 countries.

WANO was created in1989 in reaction to the Chernobyl accident of 1986. It has regional centres, which operate separately, in Atlanta, Paris, Moscow and Tokyo with a Coordinating Centre in London.

# Bruce A Restart

## *The challenge of retubing*

by Rob Liddle, Bruce Power

***Ed. Note:** We thank Rob Liddle of Bruce Power for the permission to reprint this report.*

It has been a summer of trial and error for the Retube Team in Unit 2 with calandria tube installation, but it is all starting to come together.

By the end of August, 90 of 480 new calandria tubes were inserted in the reactor and 79 were ready to receive new fuel channel assemblies. On the east end of the reactor, inserts were rolled on all but three of the positioned tubes to secure them into allotted grooves in the tubesheet bores, while ten remained on the west end. Vacuum tests to verify correct installation were underway with 166 sites successfully completed.

It hasn't been easy.

Physical installation of the tubes got underway on June 20 with plans to install the top four rows in the reactor and then pause to review the methodology. The installation was suspended on July 2 however, when a calandria tube positioned in channel B15 became partially dislodged during final alignment. The tube was successfully removed on July 9.

A root cause analysis of the incident was conducted by a corrective action team and the results were rolled out to relevant staff and trades in early August. Processes and procedures were changed, tools were made more robust, and the team was realigned to capitalize on experience.

Calandria tube installation involves a number of steps. Prior to insertion, laser tools are used to measure each of the 960-tube sheet bores, as well as to conduct tubesheet to-tubesheet measurements. This work was completed on July 26.

Each new tube has to be cleaned and trimmed to correspond with its preassigned site in the reactor. This work is completed in a special 'Clean Room' in the North Warehouse and then the tubes are shipped on a just-in-time basis to the station.

Trades people using manually driven tools on automated platforms at both ends of the reactor, guide the tubes into position, generally two rows in a series. Calandria tube inserts are then positioned and the ends of the tubes are rolled into grooves in the tube sheets. Vacuum testing follows to ensure a leak tight seal.

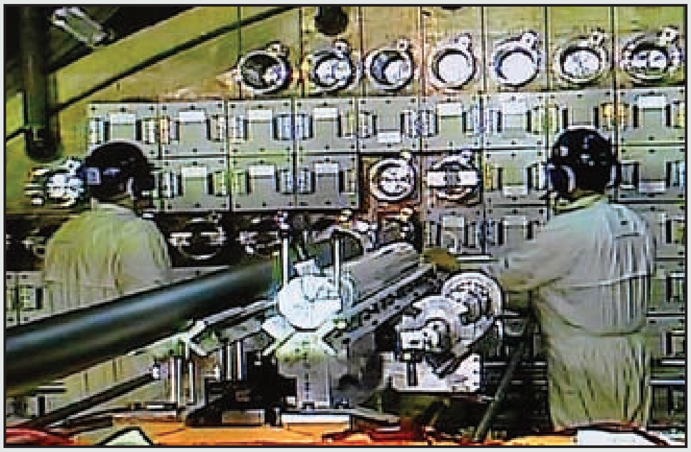
At the end of August, the team was slightly ahead of their current schedule and expected to progress down to Row S on the reactor before switching to the installation of new fuel channel assemblies. This will leave room on the lower portion of the reactor for a separate team to remove any accumulated debris from the calandria.

Individual calandria tubes have been changed out a few times in CANDU history, but this is the first time for an entire reactor's worth.

In Unit 1, the last of the original calandria tubes was removed from the reactor on March 4. Crews have since been prepping the vessel for new components, a process that took nine months in Unit 2.

*(Go to the Bruce Power website for excellent reports on the Bruce A Restart program.)*

*(Ed. P.S. The CNSC will be considering approval to load fuel into Bruce A units 1 and 2 at a Hearing scheduled to be held in Port Elgin, Ontario, September 30, 2009.)*

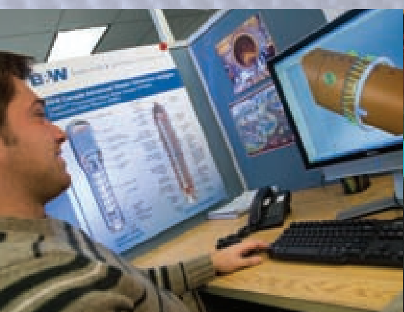


*View of reactor face of Bruce unit 2 during installation of calandria tubes.*

*Hon. Geoff Regan, MP for Halifax East and Natural Resources Critic for the Official Opposition, visited the Bruce A Restart Project in August. He is pictured in front of the Unit 1 reactor with Murray Elston, Vice President of Corporate Affairs for Bruce Power.*

# Delivering Proven Results

## for the nuclear industry




## Engineer • Manufacture • Construct • Service

For over 50 years, Babcock & Wilcox Canada Ltd. (B&W Canada), has been engineering, manufacturing, constructing and servicing for the nuclear industry around the world.

Our reputation for innovation and engineering is unparalleled in the industry. Worldwide, more than 299 B&W steam generators, as well as other equipment have been awarded or supplied.

B&W Canada has a reputation for outstanding performance, and we continue to provide nuclear services that keep your plant operating efficiently with minimal downtime.

B&W Canada offers complete engineering capabilities for nuclear equipment systems by highly experienced, field-oriented engineers. As a company with extensive experience in the construction business, B&W Canada is your best choice for the delivery of construction projects.

We are proud of our expertise, experience and commitment to excellence in customer service as we continue to build on our reputation for quality and innovative solutions.

Visit our website at www.babcock.com/bwc for more information, or call 1-866-445-6293

B&W babcock & wilcox canada ltd.

**www.babcock.com/bwc** **1-866-445-6293**

# Inspecting the Darlington Vacuum Building

In the spring of 2009 Darlington NGS conducted an inspection and maintenance of a key component of the station's safety system – its vacuum building.

The vacuum building is a 75 metre tall cylindrical structure made from reinforced concrete. It is connected to each of the four containment buildings by a large concrete duct.

The interior is kept at a near perfect vacuum. It is designed to receive the steam from a large reactor pipe failure. In the event of a rupture in the piping in any of Darlington's four reactors steam from the break would be automatically sucked into the vacuum building and condensed into water – preventing any steam pressure build-up.

The Operating Licence for the station requires that the vacuum building be inspected every 12 years. To do so necessitates all units to be shut down. The outage to do the vacuum building inspection was chosen to be done in the spring, the time of lowest electricity demand in Ontario.

Following more than two years of preparation the Darlington Vacuum Building Outage (VBO) was launched on April 15 and completed on May 25. It was the largest and most complex project of 2009 for the station.

OPG started planning for the VBO in 2007. Leading up to the outage, more than 7,000 pre-requisite tasks were completed to help ensure a smooth launch. Extensive communications and briefings were conducted to enable all staff to fully understand their role in making the outage a success. An Outage Control Centre (OCC) was established to facilitate, coordinate and manage the thousands of tasks associated with the project.

To manage the huge outage effectively, OPG broke it down into five phases. Transition periods between one phase and the next allowed independent verification that all critical tasks were completed safely prior to starting the next phase. The phases were:

Phase 1 – Preparation (Jan. 2007-April 15, 2009)

Phase 2 – All Darlington Units are shut down (launched April 15)

Phase 3 – Vacuum Building taken out of service and inspected (launched April 26)

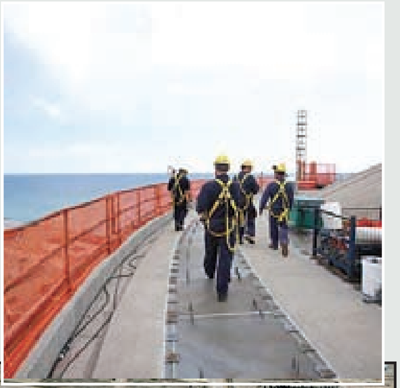
Phase 4 – Vacuum Building Inspection and Maintenance (launched May 3)

Phase 5 – Start-up of Units 4, 1 and 2 (launched May 13) (Unit 3 remained down for annual inspection)

Over 4,000 people participated in the VBO. They included Darlington employees, contractors, OPG's nuclear support staff, and employees from OPG's Pickering nuclear station. OPG's fossil and hydroelectric business units also contributed by maintaining superb performance, reliability and availability throughout the outage period.

Inspections and tests of the vacuum building indicated that its overall condition is very good. The vacuum building and associated systems were put back into service confident that they will remain sound until its next scheduled inspection in 2021.

*Outage staff on top of the Vacuum Building: To prepare for the outage, hoisting and rigging equipment were brought in, and a temporary elevator was erected to allow crews to access the roof.*



*An aerial view of the Darlington station. The vacuum building is the large cylindrical structure in the right foreground.*

# CNS news

## Meet the President

As President of the Canadian Nuclear Society for 2009 – 2010, Eleodor (Dorin) Nichita brings an international background, strong academic credentials, a fresh perspective and an engaging sense of humour. He is the 29th president since the creation of the Society in 1979 (one president served two terms).

Born and raised in Romania, Dorin went to the USA for graduate studies before being enticed to come to Canada to work for Atomic Energy of Canada Limited. He is now an Associate Professor at the University of Ontario Institute for Technology (UOIT) in Oshawa, Ontario.

Dorin was born in 1964 in Buzau, Romania, which he describes as a "small town" of 50,000, with the distinction of being over 1500 years old. Adding to that historic context, Dorin notes that his high school was well over a century old. Perhaps that historic environment gave him the perspective he displays in dealing with issues.

He says he was interested at an early age in things technical and offers this example:

Already into teleconferencing at age 2.

> *As a small boy I tended to be fascinated by the mechanical workings and electrical motors that powered my battery-operated toys. This curiosity manifested itself mostly by my taking apart those toys, using mainly a screwdriver and pliers. Once I took them apart, I had little interest in putting them back together since now I already knew how they worked. This was regarded with benevolence by my father (who was an engineer) and was, to some extent, encouraged. A line had to be drawn when I took apart the family reel-to-reel tape recorder.*

That technical interest led him to attend the University of Bucharest where he obtained a degree in Engineering Physics in 1988. He then joined the Institute for Nuclear Research in Pitesti, Romania in 1988. There, among other projects, he developed codes for fuel management for the CANDU nuclear plant at Cernavoda, Romania, and prepared a report on using slightly enriched uranium fuel in CANDU reactors.

More importantly, while working in Pitesti he met the love of his life, Daniela, whom he married in 1992. For some reason or other, shortly after getting married he began to think about pursuing graduate studies and chose the Georgia Institute of Technology ("Georgia Tech") in Atlanta, Georgia, USA. He and Daniela moved there in 1993.

Dorin obtained his Ph.D. from Georgia Tech in December 1997. Having conducted studies related to the CANDU plant in Romania Dorin applied to Atomic Energy of Canada Limited and was quickly accepted. However, AECL mailed the offer of employment to the wrong address so Dorin accepted a position in the USA with a company developing computer programs for financial investments. When communication with AECL was finally established he left the financial world for that of reactor physics. He wryly comments that in doing so he gave up the chance to become rich, but has no regrets.

At the Sheridan Park offices of AECL, Dorin worked on developing computational methods for the Advanced CANDU Reactor (ACR) including the development of the CANDU core simulator (RFSP). He was very involved in the development of

*In the lab at UOIT.*

*Daniela and Dorin on the Tennessee River, 1994.*

*1996 was Dorin's "year of the beard".*

the CERBERUS program, wrote the theory manual and prepared and presented the training lectures for the safety analysis group of Ontario Power Generation.

Although happy at AECL he was lured to the new UOIT that had been established in 2003. So, just a year later, 2004, Dorin moved to academia and joined the UOIT Faculty of Energy Systems and Nuclear Science whose Dean is George Bereznai, a long-standing member of the CNS. Over the past five years Dorin has developed and taught a number of undergraduate courses such as Nuclear Physics, Reactor Kinetics, and Nuclear Reactor Design and courses for similar subjects for the Masters program that began in 2008.

While claiming not to be athletic Dorin, and Daniela, play tennis, both regular tennis and the indoor version, table tennis. They also enjoy hiking. Perhaps appropriate for a mathematician, Dorin admits being intrigued with the interactive computer games such as Wii.

As noted in his comments on being elected CNS president (see June issue of the Bulletin) Dorin is interested in establishing (or re-establishing) a Canadian Nuclear Journal and is seeking input from members. And, unlike most of his predecessors, he supports the idea of CNS speaking out on nuclear issues.

In his role as 1st Vice-President last year Dorin very effectively chaired the committee for the 2009 Annual Conference held in Calgary in June. The choice of that venue presented many challenges but Dorin and his committee managed to achieve the most successful conference in the CNS history.

As well as that experience Dorin has demonstrated his ability as a chairman in the two Council meetings that have been held since he assumed the presidency. Under his leadership the Society will undoubtedly meet the challenges of our uncertain nuclear environment.

*Dorin's other career, sound mixing.*

*Hiking in the Smoky Mountains, 2007.*

# CNS and WiN sign agreement

*Cheryl Cottrill presents the WiN Canada Strategic Action Plan 2009-2013 to the CNS Council at its meeting 21 August 2009.*

At its August 21, 2009 meeting, the CNS Council agreed to sign a Memorandum of Cooperation with Women in Nuclear Canada and its parent organization, Women in Nuclear Global.

Susan Brissette, President of WiN Canada and Cheryl Cottrill, Executive Director were present for the ceremony.

The two organizations have been cooperating in several activities over the past few years and the question of a formal agreement has been discussed for some time. One problem was the fact that neither WiN Canada nor Win Global are incorporated. WiN Canada operates under the umbrella of the Canadian Nuclear Association while WiN Global does so under the World Nuclear Association. However, when it was recognized that the Memorandum of Cooperation does not involve any financial obligations (other than allowing two members of each organization to attend conferences with no registration fee) the CNS Council decided to proceed with a Memorandum of Cooperation with WiN Global and its affiliate WiN Canada.

Susan Brissette signed for Women in Nuclear Canada and Dorin Nichita for the Canadian Nuclear Society

The Memorandum of Cooperation is basically similar to agreements that the CNS has with other nuclear societies around the world. It covers notification of conferences, exchange of information and mechanisms for cooperation on topics of mutual interest.

During the visit of the WiN Canada delegates, Cheryl Cottrill outlined WiN Canada's "Strategic Action Plan 2009 – 2013". This includes four objectives:

- Business Literacy - educate members on all aspects of the nuclear field;
- Outreach – to reach out to women opinion leaders and to promote science to young girls;
- Career Promotion – to promote career and leadership opportunities;
- Networking – to strengthen the network within WiN Canada and increase awareness of WiN.

Strategies have been identified to achieve the desired objectives.

*CNS President Dorin Nichita and WiN Canada President Susan Brissette shake hands after signing a Memorandum of Cooperation between their two organizations, 21 August 2009.*

# CSA seeks nuclear participants

Two representatives of the Canadian Standards Association, Andy Kwong and Sarah Mokry, attended the CNS Council meeting August 21, 2009 to outline the organization's activity in the nuclear field and to seek participation in its programs by individuals with appropriate technical expertise.

The CSA is the major standards setting body in Canada. It currently has over 9,000 members who participate in various aspects of the standards development program.

The program for developing standards in the nuclear field has the following structure:

- Nuclear Strategic Steering Committee
- Technical Committees
- Technical Sub-Committees
- Task Forces

John Froats, president of CANDU Owners Group, is chair of the Nuclear Strategic Steering Committee.

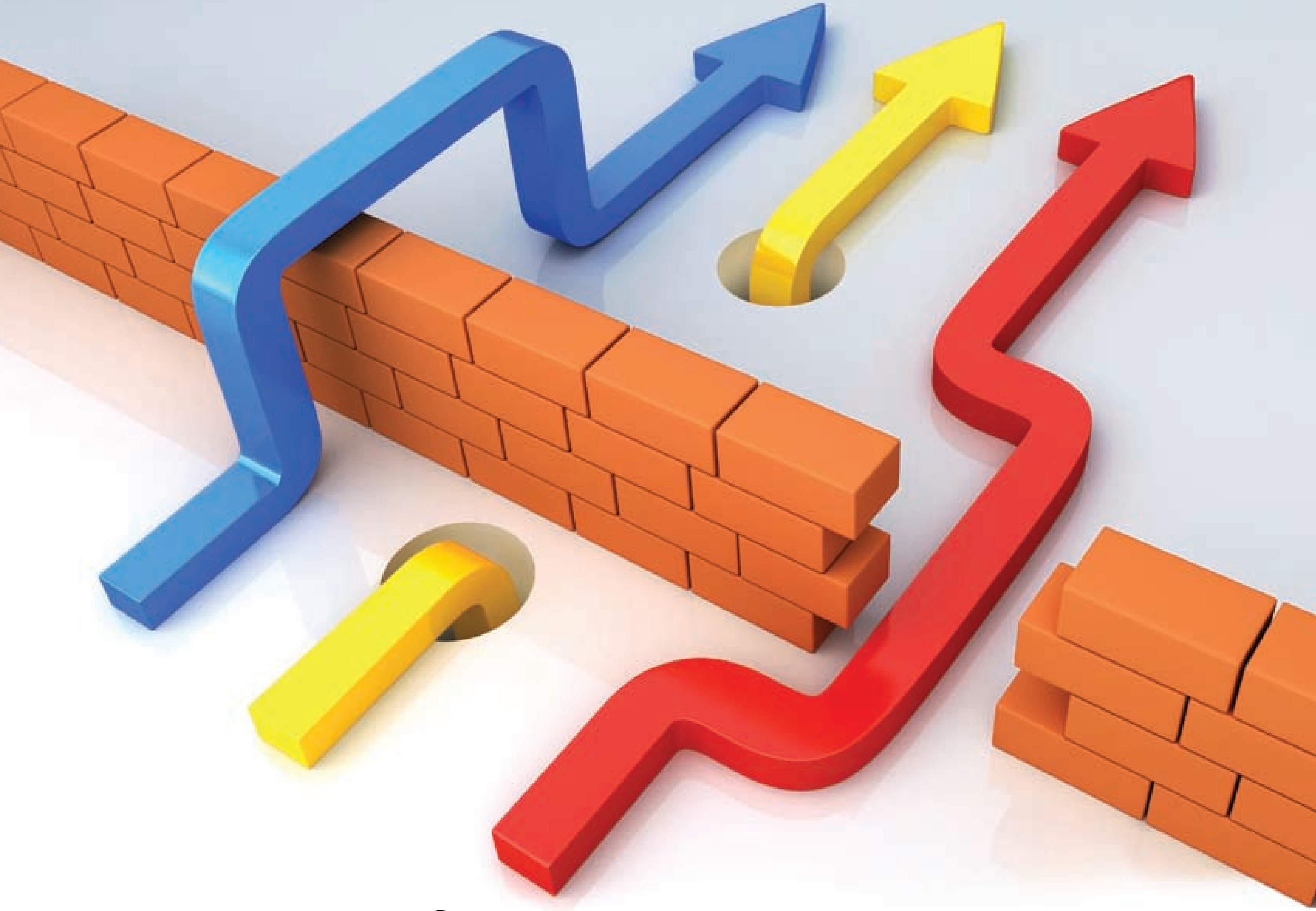
The membership of each of the committees is made up of a balance of representation from different segments of the industry and society with between 2 and 4 representatives from each of the following categories:

- General Interest
- Government / Regulatory
- Owner / Operator / Producer
- Supplier / Fabricator / Contractor
- Service Industry

Since, like the nuclear industry in general, a significant proportion of the current CSA membership is approaching retirement, the organization is seeking new younger members who would be interested in serving on the technical committees, sub-committees and task forces. Obviously, the support of their employers is required and efforts are being made in that direction. Participation in the development of standards can be a challenging and interesting activity.

In essence the message was to encourage members of the CNS to consider helping develop needed nuclear standards.

Further information can be found at the CSA website: www.csa.ca



# 3rd Annual WiN Golf Tournament

By Liz Alderson, AMEC NSS Limited

WiN members participated in the 3rd annual WiN Canada Golf Tournament, held on September 4, 2009 at the Castlemore Golf Club in Brampton, Ontario. It was a 9-hole shotgun start and best ball competition for 63 members from 14 companies including AECL, AMEC NSS, Kinectrics, OPG, Bruce Power, Cameco, COG, AECL CRL, Merlin General, OCI, SNC-Lavalin, Elementary Engineering Education Services, Ian Martin and Ryerson University.

There were of course the usual "fixed game scandal" concerns when the prize for the most honest team included members of the WiN Committee. The winner of the longest ball prize went to OPGs Janet Donegan. Closest to the pin was Rumina Velshi also of OPG.

The "sportsperson of the day" mention goes to Helen Shi of AMEC NSS, who to the surprise of all (including herself since this was Helen's first ever game of golf) played a great round.

Providing an opportunity to soak up some late summer sunshine, the day proved extremely enjoyable. Following the competition, a barbecue dinner provided a social setting for networking, announcements of winners and dinner conversion covered hot topics including new build, something on everyone's mind of late and the upcoming "Young Women's Lunch & Learn – What does an Engineer do?" mentoring event to be held in conjunction with Toronto, Peel and Hamilton District School Boards.

With prizes ranging from a golf bag to a rather "fetching" singing novelty toy, a charity raffle held to raise funds for Halton Women's Place (a charity organisation providing shelter for vulnerable women) raised $300.

Our thanks go to our events main sponsor, Kinectrics, and all the companies who donated door prizes.

## NEWS FROM BRANCHES

(Most CNS Branches are more or less dormant in the summer – even the non-summer experienced in Eastern Canada this year. Following are reports from those that had some activity.)

### ALBERTA – Duane Pendergast

Alberta Science Teachers Conference: Paul Hinman, Bryan White and Peter Lang are contemplating plans to participate in the ATA Science Teachers Conference again this year in November.

Alberta Catholic Church Website: The Alberta Branch has sent a letter to Alberta Catholic Church Archbishops requesting an opportunity to counter several myths about nuclear energy which have been posted on the Catholic Church sponsored website. Archbishop Smith of the Edmonton Diocese has responded positively and a follow-up telephone discussion was scheduled for August 17.

BP – Inside Education: BP (British Petroleum – Beyond Petroleum) is sponsoring a teacher's conference on energy from August 17-20 at the Kananaskis Delta Lodge west of Calgary. The Alberta Branch was asked to provide educational information on nuclear energy by Inside Education – an Alberta charitable organization that organized the event on behalf of BP.

Inside Education became aware of CNS in Alberta at the teachers science conference in Calgary last fall. Members Cosmos Voutsinos, Paul Hinman, Jason Donev, and Duane Pendergast participated on August 18th with support from CNA and Bruce Power Alberta. Albert Cooper presented a display from Bruce Power. CNA provided educational material for the teacher participants.

### CHALK RIVER – Ragnar Dworschak

Evening Seminars Planned:

- Deep River Science Academy joint lecture series in July:
- Jeremy Whitlock – July 9 - Splitting Atoms, Canadian Style
- Ted Clifford – 16 July - How to Live Long and Prosper
- Rosaura Ham-Su – 23 July - Energy Harvesting Materials to Power Today's Devices
- Bill Diamond – 30 July - Critical Thinking in Science
- Fall: Simon Ellison, Richard Nishimura
- John Duke (U. of Alberta) - SLOWPOKE in Alberta – TBD
- Ron Mitchel (AECL) – TBD
- George Legate (Nu-Tech) – TBD
- John Marsh, Hybrid-Electric Vehicles – TBD
- Pamela McKay (ret. NB Power) – TBD
- Hold joint events with NA-YGN and WiN: We are in communication with Ruth Allen (Kinetrics), Pauline Watson (AMEC), June Connell (NB Power), and Bernice Lanigan (NB Power).
- Education and Outreach
- Deep River Science Academy

The names of the two winners of the CNS Award for the DRSA: Kriti Kumar (Ottawa); Yang Xu (Ottawa).

Both were provided with an award of $200 each.

They were also given letters of congratulation from the CNS Chalk River Branch, along with membership forms.

The organizers for the DRSA may have also distributed membership forms to all DRSA students to encourage them to join the CNS.

The DRSA graduation was held on Saturday, August 8, 2009 in Deep River at Mackenzie High School, Child's Auditorium. There were 17 DRSA graduates.

### Community Communications – from Morgan Brown:

Nuclear History ... 59 years later

Stephen Whelan was an operator at Chalk River Nuclear Laboratories (then a division of the National Research Council), killed in an industrial accident (a chemical explosion in a liquid waste evaporator) at CRNL on December 13 1950.

In July 2009 Jeremy Whitlock, Morgan Brown and Michael Stephens met with members of Stephen's family, with a survivor of the accident, and with the family of another survivor (who has more recently died). We represented the CNS, and not our employer AECL. We hoped to address some of their concerns about the accident (there are some hard feelings and misunderstandings amongst the families), fill in some blank spots, and put a "human face" on the Canadian nuclear industry. I believe we accomplished this.

The most poignant, and perhaps most important, part of the meeting was being able to reassure Rita that her husband had not done anything wrong; he had not caused the accident. This was a concern she had for decades, and we were able to correct that misconception. That made it all worthwhile.

### NEW BRUNSWICK – Mark McIntyre

The first meeting of the fall of the New Brunswick Branch will be held September 23 with guest speaker Curt Nason.

### OTTAWA – Mike Taylor

Thanks to Program Chair, Ron Thomas, the program for the fall of 2009 has been arranged. The first Branch meeting of the fall will be held Tuesday, October 6, with guest speaker, Frank Doyle, Director of Research and Development at CANDU Owners Group.

After examining alternatives, the executive of the Branch has decided to continue meeting primarily at the RCAF Mess in downtown Ottawa as no better accommodation has found.


The next **International Conference on Water Chemistry of Nuclear Reactor Systems** focuses on the latest developments in the science and technology of water chemistry control in nuclear reactor systems. What began in the UK in 1977 as the Bournemouth Conference Series has of late been held biennially under the organization of a host country. For 2010, that country is Canada. The Conference is a forum where utility scientists, engineers and operations people can meet their counterparts from research institutes, service organizations and universities to address the challenges of chemistry control and degradation management of their complex and costly plants for the many decades that they are expected to operate. In 2010 the focus will be on operating experience and the subsequent lessons to be learned, with supporting material on new developments and research.

## Features of the Conference

**Quebec City** – the Conference will be held in the heart of Old Quebec City, which in 2008 celebrated its 400th anniversary. The city is renowned for its old-world charm, history, fine cuisine and as the centre of the Province's unique and very dynamic culture.

**Loews le Concorde Hotel** – located within minutes walk from the heart of old Quebec City, is the perfectly located and appointed venue.

**Conference Format** – four days of single session presentations with Poster Sessions that will be promoted as part of the Technical Sessions. All Proceedings will be in English.

**Walking Tours of Old Quebec City** – in various themes and languages; and possibly for your consideration, a **Canadian Forests in Autumn Excursion**.

## Call for Papers

Technical Paper Abstracts are invited in the following topic areas. There is special interest in the experience of plants with Alloy 800 as well as of those with Alloy 600 and Alloy 690 steam generator tubing.

Chemistry and NPP Performance
PWR, VVER Operating Experience
CANDU/PHWR Operating Experience
Pressurised Water Scientific Studies
Steam Cycle Operating Experience

BWR Operating Experience
Boiling Water Scientific Studies
Water and Waste Treatment, Cooling Water Systems, Auxiliary Systems
Materials Aging and Mitigation of Degradation
Chemistry and Fuel Performance

Cleaning and Decontamination
Lifetime Management
Chemistry Optimization Programs
Chemistry Compliance Management
Future Developments (GEN IV), Supercritical Water

## Radiolysis, Electrochemistry & Materials Performance Workshop

The 8th Int'l Radiolysis, Electochemistry & Materials Performance Workshop will be held as an associated, but otherwise free-standing, event on Friday, October 8, 2010. Requests for "Invitation to Present" should be submitted as for NPC 2010 but specifically for the Workshop. Separate Workshop Proceedings will be issued. For organization and registration information regarding this Workshop, see the website at **www.cns-snc.ca**

## Milestone Dates

| | |
|---|---|
| Abstracts Due | 2009 November 16 |
| Author Notifications | 2010 January 29 |
| Advance Program | 2010 January 29 |
| Papers Due | 2010 June 25 |
| Conference | 2010 October 3 to 7 |
| Workshop | 2010 October 8 |

## Abstract Submission

All prospective Authors are invited to submit a 500-word Abstract by the above date. Abstracts may be submitted via the link at **www.cns-snc.ca**. All Abstracts MUST be submitted electronically in Microsoft Word format.

All Papers are due by the above date. Authors will be provided guidelines for full Paper presentation and submission at the time of author notification.

If you have technical questions about abstracts for NPC 2010 please contact: Peter Angell, Technical Program Chair (angellp@aecl.ca).

For technical inquires regarding the Workshop please contact: John Roberts, Workshop Chair (alchemy@tnt21.com).

## Event Administrator – The Professional Edge

If you require assistance with submissions or anything else related to NPC2010, please contact: Elizabeth Muckle-Jeffs (Elizabeth@theprofessionaledge.com)

## Conference Sponsor and Organizer

**The Canadian Nuclear Society** is pleased to serve as the sponsor and organizer of the NPC 2010 Conference, which is held in cooperation with the International Atomic Energy Agency.

# News for members/ Nouvelles pour les membres

Dear CNS members:

Good news: there will be **no** increase in membership fees for 2010!

Chers/Chères membres de la SNC :

Bonne nouvelle : les frais d'adhésion **n'augmenteront pas** en 2010 !

---

Canadian Students:

**It pays to be a member of the CNS and maintain your membership!**

- Not only is your membership complimentary while you are a full-time student at a Canadian university or school (including for the year in which you graduate), but also
- If you are a member in good standing in the year when you graduate, then you are entitled to a 50% discount in regular-member fees for the following 2 years!

Étudiants canadiens :

**Être membre de la SNC et maintenir votre adhésion en bonne et due forme présente beaucoup d'avantages!**

- Votre adhésion est gratuite tant que vous êtes étudiant(e) à plein temps dans une université ou école canadienne (y inclus pour l'année où vous obtenez votre diplôme), mais aussi
- Si vous êtes membre en bonne et due forme dans l'année où vous obtenez votre diplôme, vous aurez droit à un escompte de 50% sur les frais d'adhésion standard pour les 2 années suivantes !

---

We would like to welcome the following new members, who have joined the CNS in the last two months, up to 2009 August 14.

Nous aimerions accueillir chaudement les nouveaux membres suivants, qui ont fait adhésion à la SNC ces deux derniers mois, jusqu'au 14 août 2009.

Natalie Pauline Sachar, Trent University/AECL
Bernice Marie Lanigan, NB Power Nuclear
Keren L. Morehead
Nabeel Salih
Chad Donald McFarlan, Atomic Energy of Canada Limited
Muhammad Bahgat Elmoselhi, Kinectrics Inc.

***Ben Rouben – Membership Chair***

## Canadian Nuclear Achievement Awards

Each year the Canadian Nuclear Society and the Canadian Nuclear Association join forces to honour individuals or groups who have made significant contributions to the Canadian nuclear program.

There are a number of categories:

- W. B. Lewis Medal – for outstanding scientific or technical achievement
- Ian McRae Award - for major non-scientific contributions
- Outstanding contribution Award – for individuals, groups or organizations that have made significant contributions towards the beneficial uses of nuclear energy
- Innovative Achievement Award – to recognize significant innovative achievement or implementation of new concepts
- Education and Communication Award to recognize significant efforts to improve the understanding of nuclear science and technology among educators, students and the public
- J. S. Hewitt Team Achievement Award – for outstanding team achievements in the introduction or implementation o new concepts or the attainment of difficult goals
- R. E. Jervis Award – to recognize excellence in research by a full-time graduate student in nuclear engineering or related field
- CNS Fellowship – to recognize significant contribution to the Canadian nuclear program and to the Canadian Nuclear Society

The formal call for nominations will be in the next issue of the CNS Bulletin but all readers are asked to look around now at their colleagues and contacts to see who deserves recognition.

## 2009

**Sept. 14-16** **CNS CANDU Reactor Safety Course**
Toronto, Ontario
website: www.cns-snc.ca

**Sept. 24-Oct. 1** **Peaceful Uses of Atomic Energy Conference**
New Delhi, India
website:
http://sites.google.com/site/peacefulatom2009
or: www.ins.india.org

**Oct. 5-7** **CNS CANDU Fuel TechnologyCourse**
Oakville, Ontario
website: www.cns-snc.ca

**Nov. 8-11** **6th International CANDU Steam Generator Conference**
Toronto, Ontario
website: www.cns-snc.ca

**Nov. 15-19** **ANS Winter Meeting & Nuclear Technology Expo**
Washington, D.C.
website: www.new.ans.org/meetings/m_64

## 2010

**Feb. ??** **CNA Annual Conference and Tradeshow**
Ottawa, Ontario
website: www.cna.ca

**Mar. 21-24** **INREC '10 – 1st Inernational Nuclear & Renewable Energy Conference**
Amman, Jordan
website: http://inrec10.inrec-conf.org
email: inrec10-conf@illinois.edu

**Apr.25-28** **2nd Canada – China Workshop on Supercritical Water-Cooled Reactors (CCSC-2010)**
Toronto, Ontario
website: www.cns-snc.ca

**May 9-14** **PHYSOR 2010, "Advances in Reactor Physics to Power the Nuclear Renaissance"**
Pittsburgh, PA, USA
website: http://www.physor2010.org

**May 17-21** **ICONE-18 18th International Conference on Nuclear Engineering**
Xi'an, China
***Call for papers***
website: www.icone18.org
email: icone18@ans.org.cn

**May 24-27** **31st Annual Conference of the Canadian Nuclear Society and 34th CNS/CNA Student Conference**
Montreal, Québec
***See Call for Papers***
website: www.cns-snc.ca

**June 13-17** **ANS Annual Meeting**
San Diego, CA, USA
website: http://www.ans.org/meetings

**Aug. 15-18** **Uranium 2010 – 3rd International Conference on Uranium;**
**40th Annual Hydrometallurgy Meeting**
Saskatoon, Saskatchewan
***Call for papers***
website: www.cns-snc.ca

**Sept. 26-29** **DD&R 2010 International Meeting on Decommissioning, Decontamination and Re-Utilization**
Idaho Falls, Idaho, USA
website: www.ans.org

**Oct 3-10** **International Conference on Water Chemistry of Nuclear Reactor Systems (NPC 2010)**
(organized by CNS)
Québec City, QC;
website: cns-snc.ca

**Oct 24-30** **17th Pacific Basin Nuclear Conference**
Cancun, Mexico
website: www.pbnc2010.org.mx

CANADIAN NUCLEAR SOCIETY® SOCIÉTÉ NUCLÉAIRE CANADIENNE

# And That's The Way It Is

by Jeremy Whitlock

And now the national nuclear forecast, coast to coast...

Unstable conditions continue to persist in most parts of the country. Forecasters warn of unpredictability and advise staying abreast of local updates as they emerge.

Powerful winds on the east coast will hang around longer than expected, although steady progress is being made by this system. The eye of this storm, centred at Point Lepreau, promises to renew the landscape significantly, and observers look forward to great improvements never before witnessed on this planet.

Meanwhile a similar storm over Gentilly, Quebec, now in its early stages, is gearing up gradually and expected to arrive in full force in two or three years. Observers are eyeing the developments further east with keen interest, as well as a similar system growing over the South Korean peninsula.

A tempest continues to rage over Ottawa, bringing with it tornadoes of changing policy that appear as directionless as they are powerful. Anti-nuclear folks taking refuge in the Prime Minister's Office have been forced out into the open, the most ignorant of these getting swept away.

Much of the fury of this maelstrom has been directed at Chalk River, a small hamlet on the Ottawa River where a couple thousand souls have weathered a steady onslaught of bad weather since about the mid-80's. Surviving despite dwindling resources and mounting responsibilities, they now find themselves in the battle of their lives. The quest to put an aging reactor back together, so it can once again drift into obscurity as the most efficient producer of radioisotopes on the planet, has called upon all the unique skills and teamwork that makes this laboratory a national treasure.

In the meantime, those fighting the flood of latter-day concern in Ottawa have touched off a veritable "Moly Rush": prospectors, young and old, are rushing to stake a claim in the new isotopic bonanza. It took a pair of young Maples, blown down in the early stage of this storm, plus the recent hobbling of NRU, to ignite this fever, and the claims are literally and figuratively all over the map. It is not likely that any will match the NRU's ability to underpin Canada's historical dominance in this market.

"You know what they say – 'a reactor in hand is better than two in the bush!' ", declare the Saskatchewan hopefuls, while others point to cutting-edge accelerator technology that may provide a province's needs, or a city.

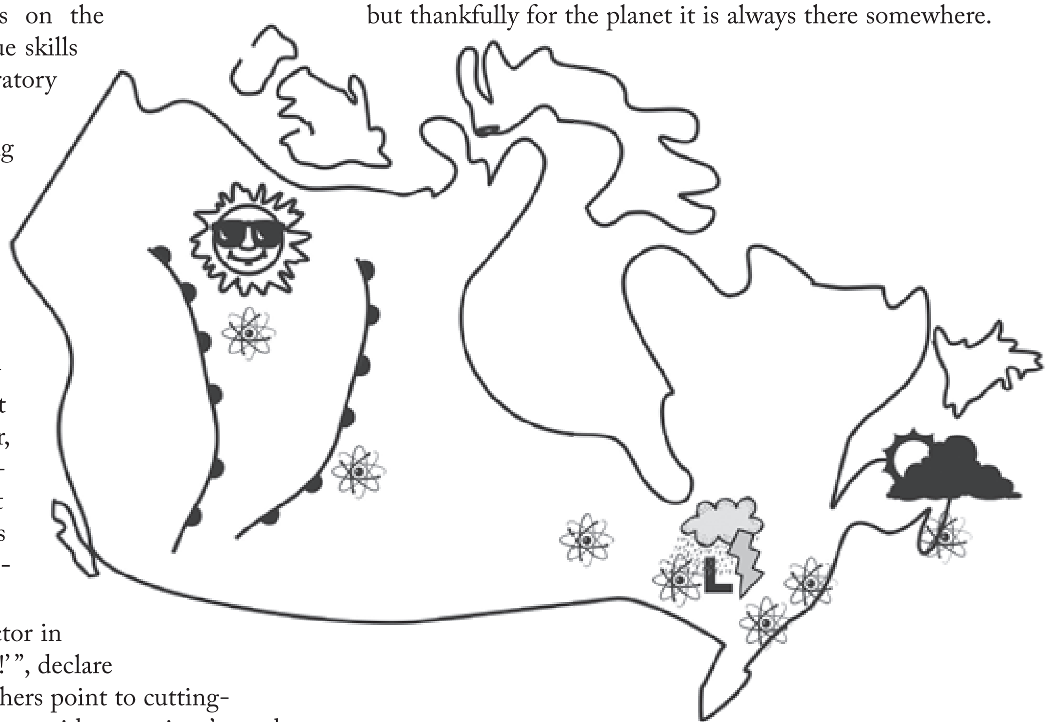
Elsewhere in Ontario, the nuclear winds have stagnated yet again. Repeating the folly of past governments, Ontario cites the economic slowdown in its rationale for luffing the nuclear sails, apparently oblivious to the fact that nuclear decisions and economic activity need to lag each other by seven to ten years. The doldrums have set in on not just Lake Huron and Lake Ontario this time, but even Lake Erie has seen an unexpected squall of massive potential extinguished as quickly as it blew in.

Looking to the west, warmer winds continue to waft though the foothills and over the prairies. Storm-watchers in Alberta and Saskatchewan keep an eye on all developing systems, but it may be a while before significant activity is seen in that quarter.

Nonetheless, they're doing a rain dance in Saskatchewan and have high hopes for sparking nuclear business higher up the food chain than they've been used to. Over in Wild Rose Country (speaking of sparking), it appears that Alberta has become the latest lighting rod for every quack on the anti-nuclear fear-mongering circuit. Snakeoil salesmen that have long outlived their tolerance in mainstream Ontario and eastward, resonate in town gatherings from Deadwood to Whitemud.

From coast to coast, a mixed bag indeed.

At least one can be content to think of the mighty jet stream up there, somewhere: an inevitable movement forward to an outcome that supersedes lies, politics and histrionics. The speed of the jet stream, and even its exact location, is often a mystery, but thankfully for the planet it is always there somewhere.



# 2009-2010 CNS Council • Conseil de la SNC

## Executive / *Exécutif*

| | |
|---|---|
| **President** / ***Président*** | E.M. (Dorin) Nichita . . . . . 905-721-8668 x2968 |
| e-mail | eleodor.nichita@uoit.ca |
| **Past President** / ***Président sortant*** | J. (Jim) Harvie . . . . . . . . . . 613-833-0552 |
| e-mail | jdharvie@rogers.com |
| **1st Vice-President** / ***1ier Vice-Président*** | A. (Adriaan) Buijs . . . . . . . 905-822-8426 |
| e-mail | adriaan.buijs@sympatico.ca |
| **2nd Vice-President** / ***2ième Vice-Président*** | F.W. (Frank) Doyle. . . . . . . 416-595-1888 x156 |
| e-mail | frank.doyle@candu.org |
| **Treasurer** / ***Trésorier*** | E.L. Williams . . . . . . . . . . . 519-396-8844 |
| e-mail | canoe.about@bmts.com |
| **Secretary** / ***Secrétaire*** | P.S. (Prabhu) Kundurpi . . . 416-292-2380 |
| e-mail | kundurpi@sympatico.ca |
| **Financial Administrator** / ***Administrateur financier*** | K.L (Ken) Smith. . . . . . . . . 905-828-8216 |
| e-mail | unecan@rogers.com |
| **Executive Administrator** / ***Administrateur exécutif*** | B. (Ben) Rouben . . . . . . . . 416-663-3252 |
| e-mail | roubenb@alum.mit.edu |

## Members-at-Large / *Membres sans portefeuille*

Parvaiz Akhtar . . . . . . . . . . .613-837-9846
Blair Bromley. . . . . . . . . . . .613-584-3311 x43676
Pierre Girouard . . . . . . . . . .905-923-9060 x36422
Ed Hinchley . . . . . . . . . . . . .905-849-8987
Krish Krishnan . . . . . . . . . . .905-997-7797
Peter Lang . . . . . . . . . . . . . .705-466-6136
James Lévéque. . . . . . . . . . .613-797-5706
Kris Mohan. . . . . . . . . . . . . .905-332-8067
Dave Novog. . . . . . . . . . . . .905-525-9140 x24904
Duane Pendergast . . . . . . . .403-328-1804
Jad Popovic . . . . . . . . . . . . .905-820-7472
John Roberts . . . . . . . . . . . .519-361-5898
Ben Rouben . . . . . . . . . . . . .416-663-3252
Len Simpson . . . . . . . . . . . .204-753-8334
Michael Stephens. . . . . . . . .613-584-3311 x44060
Murray Stewart . . . . . . . . . .416-590-9917
Jeremy Whitlock . . . . . . . . .613-584-8811 x44265
Mohammed Younis . . . . . . .416-592-6516
Syed Zaidi . . . . . . . . . . . . . .613-584-3311 x43692

## CNS Committees / *Comités de la SNC*

**Program / Programme**
Frank Doyle . . . . . . 416-595-1888 x156 frank.doyle@candu.org

**CNA Interface / Interface avec l'ANC**
Colin Hunt . . . . . . . 613-237-4262 x103 huntc@cna.ca

**WiN Interface / Interface avec WiN**
Jad Popovic. . . . . . . . . . . 905-820-7472 popovic@rogers.com

**Branch Affairs / Chapitres locaux**
Syed Zaidi. . . . . . 613-584-3311 x43692 smh@zaidi.net

**Education and Communications / Éducation et communications**
Jeremy Whitlock 613-584-8811 x44265 whitlockj@aecl.ca
Peter Lang . . . . . . . . . . . . . . . . . . . . . . . plang@drlogick.com

**Membership / Adhésion**
Ben Rouben . . . . . . . . . . 416-663-3252 roubenb@alum.mit.edu

**Finance / Finances**
Ed Hinchley . . . . . . . . . . 905-849-8987 e.hinchley@ieee.org

**Past Presidents / Anciens présidents**
Jim Harvie. . . . . . . . . . . . 613-833-0552 jdharvie@rogers.com

**Climate Change and The Nuclear Future / Changement de climat et avenir nucléaire**
Dan Meneley . . . . . . . . . 705-657-9453 daniel.meneley@uoit.ca

**Honours and Awards / Prix et honneurs**
Doug Hink . . . . . . . 905-829-8808 x301 dhink@adhtechnologies.ca

**International Liaison / Liaisons internationales**
Kris Mohan . . . . . . . . . . . 905-332-8067 mohank@sympatico.ca

**Internet / Internet**
Morgan Brown . . 613-584-8811 x44247 brownmj@aecl.ca

**Inter-society Relations / Relations inter-sociétés**
Adriaan Buijs. . . . . . . . . . 905-822-8426 adriaan.buijs@sympatico.ca

**Young Generation / Jeune génération**
To be confirmed / À confirmer

**Representative to PAGSE / Représentant auprès de PAGSE**
Fred Boyd. . . . . . . . . . . . 613-592-2256 fboyd@sympatico.ca

## Technical Divisions / *Divisions techniques*

- Nuclear Science & Engineering / Science et génie nucléaires
  John Luxat 905-525-9140 x24670 luxatj@mcmaster.ca
- Fuel Technologies / Technologies du combustible
  Joseph Lau 905- 823-9060 x34531 lauj@aecl.ca
  Erl Køhn 416-592-4603 erl.kohn@amec.com
- Design and Materials / Conception et matériaux
  Ian Trotman 905-403-7585 trotmani@aecl.ca
- Environment & Waste Management / Environnement et gestion des déchets
  Ken Dormuth 905-569-2306 kwdormuth@rogers.com
- Nuclear Operations & Maintenance/ Exploitation nucléaire et entretien de centrale
  Paul Lafrenière 416-595-1888 x158 lafrenierepaul@sympatico.ca

### CNA Liaison / *Agent de liaison avec l'ANC*
Colin Hunt 613-237-4262 x103 huntc@cna.ca

### CNS Bulletin Publisher / Éditeur du Bulletin SNC
Fred Boyd 613-592-2256 fboyd@sympatico.ca

### CNS Bulletin Editor / Rédacteur du Bulletin SNC
Ric Fluke 416-592-4110 richard.fluke@amec.com

### CNS Webmaster / Webmestre de la SNC
Morgan Brown 613-584-8811 x44247 brownmj@aecl.ca

### CNS Office Manager / Administratrice du bureau de la SNC
Denise Rouben 416-977-7620 cns-snc@on.aibn.com

## Branches / Chapitres locaux

| | | | |
|---|---|---|---|
| **Alberta** | Duane Pendergast | 403-328-1804 | still.thinking@computare.org |
| **Bruce** | John Krane | 519-361-4286 | john.krane@brucepower.com |
| **Chalk River** | Ragnar Dworschak | 613-584-8811 x44342 | dworschakr@aecl.ca |
| **Darlington** | Jacques Plourde | 905-623-6670 x1577 | jacques.plourde@opg.com |
| **Golden Horseshoe** | Dave Novog | 905-525-9140 x24904 | novog@mcmaster.ca |
| **Manitoba** | Jason Martino | 204-345-8625 x244 | martinoj@aecl.ca |
| **New Brunswick** | Mark McIntyre | 506-659-7636 | mmcintyre@ansl.ca |
| **Ottawa** | Mike Taylor | 613-692-1040 | brutust@rogers.com |
| **Pickering** | Marc Paiment | 905-428-4056 | marc.paiment@opg.ca |
| **Québec** | Michel Saint-Denis | 514-875-3452 | saintdenism@aecl.ca |
| **Saskatchewan** | Walter Keyes | 306-586-9536 | walter.keyes@sasktel.net |
| **Sheridan Park** | Peter Schwanke | 905-823-9040 | schwankep@aecl.ca |
| **Toronto** | Joshua Guin | 416-592-7706 | joshua.guin@amec.com |
| **UOIT** | Abuzar Fariad | 416-784-3331 | abuzarf@gmail.com |

## CNS WEB Page - Site internet de la SNC

For information on CNS activities and other links – Pour toutes informations sur les activités de la SNC

**http://www.cns-snc.ca**