CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

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William Gordon "Bill" Morison
1926 – 2016

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Nuclear Energy in a "Post-Truth" World of Communications

There are new lexicons in the media lately, such as fake news, alternative facts, and a proliferation of Twitter usage to present "news". But overwhelmingly, we see in various media a shortage of truth (i.e. facts that can be verified); instead we see emotive descriptions, that is, information not based on fact but on the feelings that are targets of the message. Of course facts are only boring data bytes when the intent is to persuade people, using emotional innuendo and rhetoric. There is a new term coined for this strategy: it's the Post-Truth era of communication.

It's an interesting term that began in 2016, but my problem is that in order to call this a "Post-Truth" era, there, by implication, must have been a previous era in which there was truth in journalism. I'm still searching for examples. As we well know, a person like Helen Caldicott can spout "alternative facts" supported only by the apparent authoritative stature that mainstream media provides.

But how do we communicate truth? Consider a headline "Childhood Leukemia linked to living near nuclear power plants!!!" The story is filled with emotion, irrelevant facts and a peppering of testimonial, but when the "data" is examined it is found to be irrelevant, altered, or used out of context, and when analyzed scientifically, the data leads to the opposite conclusion. The scientific finding, published in a peer-reviewed medical journal, is later "summarized" by the media in fine print near the back of the newspaper, or on the regulator's website which is simply dismissed as "biased".

The Globe and Mail [November 13, 2007] reported that residents of Port Hope tested positive for uranium in urine samples. That part was truth. But it caused a public outcry, claims of regulator ineffectiveness, calls to shut down nuclear stations and demands that Cameco compensate people for what was said to be certain death by cancer. Tourism and property values also suffered. But in context it was fake news because it was irrelevant, misleading and concealing of other facts: the uranium concentrations found in Port Hope residents were the same as found in residents anywhere in the world where people drink water.

The Guardian (UK) [3 February 2017] reported "alarming and unimaginable" increases in radiation levels in the Number 2 unit of Fukushima. The levels were indeed higher than previously reported, but that is simply because the newer levels were taken much closer to the core, and were certainly not "unimaginable" to those who have knowledge of levels measured at Chernobyl and those who are adept at calculation. The "alarming" part of the news was how it was reported in a Post-Truth era of journalism.

Science Magazine [4 March 2016] reported on the unexpected incidence of thyroid abnormalities among Japanese children since the Fukushima accident and quoted Helen Caldicott as claiming it was most certainly the consequence of iodine released from the accident. However, *Science* also concedes that the result is an "ironic result of a well-intentioned screening program". Seek and ye shall find. Other media chose to focus on Caldicott's unsupported claim.

Sensationalism used in the media (social media or mainstream) attracts a *click* to the site, which advertisers pay money for. So, Post-Truth could be a money making opportunity! But the public deserves better.

In This Issue

2016 was a year of loss of many notable celebrities and heroes, but one great loss to the nuclear industry was Bill Morison, remembered by many for his remarkable career in nuclear engineering and the success of the CANDU nuclear power development. It is only fitting that the CNS Bulletin devotes a small space for a big person by remembering our dear friend and colleague.

In our third look at the important role of women in the Montreal Laboratory Gilles Sabourin has provided Part III of his research. Not only does it provide an introspective look into the forgotten contributors to the success of our nuclear industry, it offers a compelling story of commitment and bravery during a time of world turmoil.

2017 is the 50th anniversary of the first electricity from Canada's historic full scale nuclear generating station, Douglas Point. We feature a history of engineering excellence, dedication and innovation that was the precursor to a successful and international endeavor to build and service CANDU™ reactors in Canada and abroad.

2017 looks to be an exciting year for nuclear; Federal ministers are upbeat, refurbishment projects continue in Ontario, more SMR's are being considered and, as suggested [see OP-ED] by a former premier of New Brunswick, Frank McKenna, there is a compelling case for the consideration of a second Point Lepreau reactor.

I hope you had a safe and enjoyable winter as we look optimistically for spring, and as always, your letters and comments are welcome.

From The Publisher

When is the last time anyone has heard Canada's nuclear sector described as a strategic asset? When is the last time anyone has heard a federal minister say to the nuclear industry that it should take as much of Canada's electricity sector as it can get? When is the last time that anyone has heard an Ontario minister say that nuclear was a critical and essential part of Ontario's advanced technology economy and a key driver in future export opportunities?

For most of us, it's been a very long time, decades in fact. But the fulsome support from both the federal and Ontario governments was on full display at the February conference of the Canadian Nuclear Association (CNA). Natural Resources Minister Jim Carr and Ontario Energy Minister Glen Thibeault were not watering their wine even a trifle. Minister Carr in describing Canada's nuclear technology as a key strategic asset indicated that nuclear formed a key part of the government's long term development strategy in a host of areas, including clean energy, high quality employment, climate strategy and advanced medical techniques and industrial research.

Mr. Carr was as refreshingly blunt as possible.

"This government gets it."

Parliamentary Secretary Kim Rudd was equally uncompromising. She noted that in her past year of international meetings, Canada has a highly respected reputation by all countries for its nuclear science and engineering.

Mr. Thibeault was equally forthcoming and uncompromising in his support for nuclear. It was considerable satisfaction that he noted that Ontario Power Generation (OPG) had started its refurbishment of Darlington Unit 2 on the button in late 2016 and that it was ahead of schedule.

At the same time, Mr. Thibeault noted his support for continued operation of the Pickering nuclear station to 2024 as a critical part of Ontario's nuclear refurbishment program. This support became even more possible with Pickering having two outstanding years in 2015 and 2016 for safety and operational performance.

And as this column has noted in previous editions, domestic development in Canada is being echoed by opportunities around the world. New CANDU reactors are in the works in Argentina, China and Romania.

And it's not just about reactors. Canadian companies are securing contracts for nuclear projects, many of them in nations for the first time, such as South Africa.

And it's not just about CANDU. Canada is becoming a home to extensive research and development of Small Modular Reactors. No less than seven SMR designs are under review by the Canadian Nuclear Safety Commission (CNSC). What's even more surprising: a number of these designs are from foreign countries, looking to Canada as a possible site for prototype development. It's happening because Canada has a large, well developed nuclear research and development infrastructure, and because Canada has a well-developed nuclear supply chain capable of meeting such needs.

It should be noted that no small part of this attraction to Canada is the efficiency and effectiveness of its regulator the CNSC and its flexibility in considering new reactor concepts.

So of course there's a buzz in the air. Billions of dollars in business, domestic and export contracts, new technology and new technology infrastructure are creating an excitement not experienced since the pioneering days of nuclear in Canada. We're even opening new research facilities with the commissioning by Canadian Nuclear Laboratories (CNL) of the new Harriet Brooks Laboratory at Chalk River.

But how different the picture when we look outside Canada to nations turning away from nuclear. California's crusade against nuclear power has resulted in soaring emissions and power costs despite huge subsidies for renewables. The early closure of Nine Mile Point in New York State means that the state has little idea of how to keep the lights on in one of the world's largest cities. Germany encountered blackout conditions this winter with the combination of its nuclear shutdown and the non-performance of its renewables.

There's an old saying, "You can lead a horse to water, but you can't make him drink." The modern energy version might be, "You can build all the turbines you like, but you can't make the wind blow."

The resurgence of nuclear in Canada is happening at just the right time. Over the course of this winter, Toshiba has effectively removed Westinghouse from any new nuclear projects. Areva's difficulties with its export project in Finland continue, not to mention similar difficulties with its project at Flamanville. The number of countries now capable of supporting nuclear export projects has now dwindled to a handful: Canada, South Korea, China and Russia.

Canada is now one of a very few countries that has the full spectrum of nuclear expertise: power reactors, uranium mining, fuel production, medical and industrial applications. Over the years, many of its competitors in nuclear have fallen or are falling by the wayside. And now new nuclear concepts are coming to Canada in the form of SMRs.

To paraphrase an old movie, "If you need nuclear, who ya gonna call?"

C.G.H.

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~ Cover Photo ~

Known simply as "Bill Morison", he was the visionary that brought the former Ontario Hydro to become North America's largest nuclear utility, with aggressive and overlapping construction schedules from prototype Douglas Point to the successful Darlington Nuclear Generating Station to meet Ontario's growing electricity demand.

Photo courtesy of Dr. R. Allan Brown

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Op Ed - Point Lepreau

by FRANK McKENNA[1]

Efforts to reduce greenhouse gas emissions provide the nuclear industry with a "tremendous opportunity" according to Canada's Natural Resource Minister, Jim Carr. He was directing his comments to a gathering of industry representatives. He could have been directing them to the entire province of New Brunswick.

That's because the construction of a second nuclear reactor at Point Lepreau is rapidly emerging as a viable energy option. Such a project would be transformational for the province. I enthusiastically support efforts to advance the file.

God knows it has been a long time coming. A second reactor was contemplated when the first reactor was completed in 1981. Considerable money was expended in preparing the site for a second reactor. Support for a second reactor was part of our energy policy in 1987.

It has had various reappearances since that time, most recently when the government of Shawn Graham initiated a study in 2007 which, unfortunately, did not survive a change of government.

Today we are witnessing the best set of conditions in recent history for a revival of the dream.

And imagine what a dream it would be for our beleaguered economy. An average of 4,000 highly paid jobs a year would be created for some five years, with as many as 5,000 at peak construction. Five hundred full time jobs would be created in the operation of the plant.

A second Lepreau would also provide interesting possibilities to reduce the provincial debt if the Province wanted to proceed in that direction. If the business case was compelling New Brunswick could monetize its existing Point Lepreau plant and allow the purchaser to proceed with building the second site. This would further transfer risk and create a more compelling business case because of the opportunity for managing both nuclear stations in a larger nuclear fleet. It would also be taxpayer friendly given that the cost to operate the facility and pay for debt would no longer be on the public books. Freed up resources could be reinvested into our health care school systems, or increase our energy baseload of renewable resources.

The benefits to the Province of New Brunswick are dramatic and readily apparent.

The Government of Canada should be at the table as well to do a loan guarantee or a backstop against cost overruns. This would reduce risk and lower the cost of financing.

There are overwhelming reasons for the federal government to support this project.

It was a federal agency, AECL, whose massive cost overruns in the refurbishment of Point Lepreau I left NB Power and New Brunswick taxpayers with a massive bill. It is also the Government of Canada's carbon policy that will result in the premature closing of Belledune necessitating a repowering of that facility or an alternative energy source.

Aside from the benefits to New Brunswick Point Lepreau II would be a national project supporting the uranium industry in Saskatchewan and large numbers of nuclear engineers in Ontario.

Also, the Government of Canada is committed to large national infrastructure projects to stimulate the economy. Our Province will not be a major beneficiary, in large part because we simply don't have the large scale initiatives that you would find in major urban centres. Point Lepreau II would be a compelling exception.

Finally, at a time when Canada urgently needs growth this project is probably more meritorious and less contentious than almost any other project on the drawing board. The successful operation of Point Lepreau I for over 30 years has created significant social license in our region for the construction of a second nuclear plant.

We also have a large skilled workforce that is readily available having been displaced from Western Canada. We have a prepared site that is worth as much as a half billion dollars.

Most importantly of all we have a large demand for non-emitting energy from New England, right in our neighbourhood, and a proposed transmission line by Emera which will run right by our door.

The stars have never been so well aligned.

It has been pointed out that political uncertainty is a problem in planning such a massive long tailed project. This may be one of those rare opportunities where the government should brief the official opposition and ask for their support. I believe that the population would enthusiastically welcome such political co-operation.

Point Lepreau II is far from a certainty. It still has to pass an unflinching scrutiny from regulators. It must produce power at competitive prices and there must be a market for that power.

We won't know the answer to these questions until we start the process.

But opportunity is knocking. At the very least, we should open the door for public discussion.

1 Frank McKenna is a former premier of New Brunswick.

In Memoriam

William Gordon "Bill" Morison, P. Eng.

Bill Morison was born in Vermillion, East of Edmonton, Alberta, Canada. He graduated from Ponoka, Alberta High School in 1944. He studied at the University of Alberta where in 1948 he graduated B.Sc. Engineering Physics. He attended Stanford University, California where in 1949 he graduated as M.A.Sc. Electrical Engineering.

Bill worked in his father's hardware store during his school years. He learned about the 7000 items sold in the store and how to interact with people in dealing with customers and salesmen. This experience would be put to good use in his later career in managing staff and interacting with associates.

Bill worked on civil construction projects in the summers before and during his time at university. He was a general foreman in charge of building a sewage plant prior to his last year at the University of Alberta. In these jobs he gained knowledge of construction practices and management.

Bill joined the Ontario Hydro Research Division in 1949 as a Research Engineer in the Applied Mechanics Section working on the movement of large structures such as Hydro dams and tunnels. In 1957 he was assigned as a Research Engineer at the Chalk River Nuclear Laboratory to continue his training and education on nuclear power technology.

At CRNL, Bill was part of a team led by Harold Smith, Chief Engineer, Ontario Hydro, that reviewed the suitability of the first design of NPD (known as NPD-1 to historians) for extrapolation to larger generating units required in the future. This team that included John Foster (AECL) and Lorne McConnell (Ontario Hydro) and others prepared a seminal report (CRNL Report NPG 10) that forms the base design for all CANDU nuclear power plants in operation today. The team recommended that the design of NPD (NPD-1) be changed from a pressure vessel reactor concept to a horizontal pressure tube reactor with on-power bi-directional refuelling (NPD-2). Natural uranium fuel and heavy water coolant and moderator would be retained. The recommendations included the construction of a 200 MWe prototype CANDU generating station.

In 1958, Bill was assigned to the Nuclear Power Plant Division of AECL. He assumed positions of increasing responsibility. As an Analyst he produced a reference design for the 200 MWe Douglas Point NGS in 1958. As a Senior Analyst he was responsible for fuel design, engineering analysis and safety analysis and in 1960 with the aid of a slide rule, he produced the two volume Douglas Point Safety Report on which the plant was licensed. It is noteworthy that when he retired in 1991, the Nuclear Safety Department in Ontario Hydro had about 200 people trying to replicate this feat for existing plants.

He was appointed Pickering NGS Study Engineer in 1963 and with his staff produced a Pickering NGS Project Outline document that featured multi-unit CANDU Power Plant composed of 500 MWe units. This formed the basis of the Pickering Station design.

In 1964 he was appointed Chief Design Engineer Pickering GS. In this position he was responsible for Pickering Station design. The design involved many innovative features including the conception and development of the Negative Pressure Containment System that is an important safety feature of all Ontario's multi-unit nuclear generating stations.

He was responsible for the study of the design of larger CANDU units in addition to his work on Pickering. In 1988 he issued a project outline for a 4 x 750 MWe station that formed the basis of the Bruce NGS station design.

The success of his work on Pickering and Bruce was a major factor on Ontario Hydro committing in 1964 to construct Pickering A and Bruce A in 1968 as part of its program to meet the projected load growth using a mix of secure and diverse fuels including uranium that is indigenous to Ontario. The electricity supply expansion program included the coal-fired stations at Nanticoke and at Lambton as well as oil-fuelled stations at Lennox and Wesleyville.

In 1969, Bill was appointed Assistant Director Generation Projects where he provided overall direction and guidance to the design process that achieved the successful completion of diverse projects such as Lambton GS, Pickering NGS A, Nanticoke GS 1-4, and other miscellaneous facilities.

In 1976, Bill was appointed Director, Design and Development Division where his overall direction and guidance led to the successful completion of Bruce NGS A, Bruce Heavy Water Plant B, Pickering NGS B, Bruce NGS B, Nanticoke GS 5-8, Arnprior GS, Lennox GS, and other projects. He was directly involved in the licensing and obtaining the several required approvals for the

operation of Ontario's nuclear generating stations.

He led delegations of Ontario Hydro and AECL staff for presentations and discussion on nuclear safety and licensing matters with the AECB, it's staff and it's Reactor Safety Advisory Committee (RSAC). He was highly respected by the AECB/CNSC senior management through his detailed knowledge of the issues being discussed and his persuasive arguments supporting Ontario Hydro's position. Often matters up for debate were resolved in favour of Bill's views.

As Director, he was responsible for several functional engineering departments and took a keen interest in developments that could improve the efficiency and reliability of the generation and delivery of electricity to the citizens of Ontario and for the protection of the environment. This interest included leadership by encouraging his staff to pursue such developments in their area of technology and by taking a personal interest in their work. He obtained funding for such development work and allocated it to the diverse development areas for which he was responsible such as nuclear stations, fossil-fuelled stations, hydro-electric stations, and grid stability, etc.

Of particular importance was that technical claims made in the safety area required a strong base of confirmed information and he was a strong supporter of the experimental programs Ontario Hydro undertook with AECL, other Canadian research facilities and with large-scale International experiments relevant to the CANDU to provide the required base.

He showed his visionary skills in having a major role in setting up the Canadian Fusion Fuels Technology Project to give Canada involvement in International Fusion Programs and in establishing the CANDU Owners Group to promote cooperation among utilities operating CANDU Stations. His vision led him to set up a Quality Engineering Department and Environmental Studies Department in his Division and to have a major role in establishing the Nuclear Integrity Review Committee that was an important part of nuclear safety management for Ontario Hydro.

Bill was a member of many committees important to the effective operation of Ontario Hydro.

He played a major role in presentations to the Royal Commission on Electrical Power Planning (RCEPP), and to the Select Committee on Hydro Affairs.

In 1983, Bill was appointed Vice-President Design and Construction for Ontario Hydro responsible for the design, development and construction of nuclear, fossil and hydraulic power stations and for transmission, transformation and telecommunication facilities. He retired from this position in 1991.

In addition to his duties at senior management levels, Bill kept in close touch with the sundry technical issues that arose during the whole period of

Scene from Bill's retirement from Ontario Hydro in 1991. L-R: Don Souther, Allan Brown, Tom Drolet, Bill Morison and Hugh Irvine.

Ed. Note: It is not clear what Tom was saying to Bill, but I believe Tom is making an animated explanation to Bill on how to spin a neutrino.

CANDU power plant development up to the mature plant designs that now benefit millions in Canada and around the world.

Bill Morison was a first class engineer and manager in a wide variety of engineering disciplines as is evidenced by his accomplishments listed above.

His innovation, experience and leadership has in a large way led to the Ontario nuclear program that provides safe, clean, economical electricity to the people of the province. It is now supplying over 60 percent of Ontario's electricity needs.

His achievements have led to him being awarded the APEO Engineering Medal in 1972, the CNA W. B. Lewis Medal in 1978, the ANS Walter Zinn Award in 1985 and the CNS Innovative Achievement Award in 1991.

Bill continued his interest in engineering and science after he retired from Ontario Hydro in 1991. He had a great interest in the nature of things that led him to investigate the role of neutrinos on atomic, electro-magnetic and gravitational forces. This resulted in him participating in establishing the Sudbury Neutrino Lab that enabled experiments leading to the award of the Nobel prize in Physics to a Canadian, Dr. Arthur McDonald.

Not only a brilliant engineer, he was a leader with exceptional managerial skills with which he could relate to his staff. He gained the admiration and respect of his staff. His engineering knowledge was admired and respected by senior management, peers, colleagues, and those others that he interacted with during his career.

He could communicate with others in many fields. He was interested in sports and could discuss the latest news of the Argos or golf. He could surprise with his comments, For example, in 1985, Bill, Paul

Bill Morison at his retirement in 1991.

Burroughs and Hugh Irvine flew to Japan in a plane in which a bomb had been placed in a piece of luggage. The bomb exploded shortly after the plane arrived killing two baggage handlers. After much delay, when eating at the cafeteria of the hotel in Tokyo music was playing over the cafeteria speaker system. Suddenly out of the blue Bill commented that the musician was Zamfir playing the pan-flute.

Bill Morison was a revered engineer, scientist and human being. He was a humble man who respected and encouraged his staff. He was a real gentleman. He will be remembered with fondness and admiration by those who knew and worked with him.

The thoughts expressed above are reflected in the following quotations from some of those who knew and worked with Bill.

Remembering Bill.

"Given the fact that Bill was assigned to CRNL as a research engineer in 1957, and remembering myself watching Bill effectively lead a big chunk of Ontario Hydro from 1972 onward from the lowly chair of Assistant Division Director and later D&D Director, I would not be a bit surprised to find that he had a governing influence within H.A. Smith's 1957 group as well as a strong influence in Hydro's decision to buy Pickering 1 and 2".

"Going from NPD to Darlington, with overlapping schedules, was an enormous undertaking..... and it took a brilliant, aggressive and skilful engineer like Bill to make it happen. He was a man of vision like no other since!"

"In addition to his well-known major contribution to the nuclear power business, I was impressed with how he never stopped thinking and challenging the accepted norm. In latter years he was challenging whether the thinking and teaching on basic magnetism was correct, and whether neutrino flux was properly understood."

"As a consultant to OH, I only had one opportunity to work with Bill and that was when he was the Chairman of the Fact Finding Committee following the Darlington fuel failures. Needless to say, I was very impressed. Obviously he knew the systems well, but in addition he was well organized, soft spoken, patient (he let everyone have their say) and technically astute. It was indeed a pleasure to work with him."

"I never saw Bill getting mad or putting someone down. He was a true gentleman.

His review turnaround on draft correspondence to the AECB was incredibly fast and prompt, usually no later than the following morning. What I found interesting was that he invariably would not have any critique on the text, but he might subtly point out or question something on a graph or chart. He was usually right.

One of my earliest memories of Bill when I joined OH was the time when I gave a talk on plutonium recycling at AECL. I had not personally met Bill yet at the time, but I knew who he was. Bill was in the audience listening to my talk. and I noticed that he from time to time would look at me and smile. It unnerved me somewhat since I did not know if he was smiling approvingly or otherwise. Bill could come across as intimidating that way if one did not know him. Once I got to know him, however, I found Bill to be one of the nicest and smartest people at OH."

"He was the rock solid anchor to the fundamentals for all of us. He gave us the time to express our opinions and the guidance we needed to keep our eyes on the long term... the guidance was gentle. Our success in the business was due to many like him in Ontario Hydro. "

"I was always impressed with his knowledge. As an anecdote I remember he wrote over a weekend the first ever design Quality Engineering manual for Ontario Hydro. It formed the basis for the subsequent QE manuals and programs in OH."

"Bill Morison, a gentleman so generous of spirit, touched my life in so many ways. As a mentor, I idolized him. As a visionary, he led us forward. As a magnificent engineer, he taught, worked, and fostered the highest level of development and competence, trustworthiness. As a manager and executive he inspired excellence and gave of himself in expectation and praise. He will forever be loved and respected."

"One day, whilst I was still a lowly MP3, I was busy

working at my desk someone quietly entered my cubicle and sat down in my visitor chair. Looking up, I saw Bill who proceeded to discuss modal spatial kinetics and control with me. This impressed the heck out of me and was something he did fairly frequently and was greatly appreciated by the surprised employees.

Another memory was from the Fifth International Meeting on Thermal Nuclear Reactor Safety held in Karlsruhe in Sept. 1984. Bill attended to present a paper titled "Containment Systems Capability"..... The conference banquet was held at Hambach castle..... The Oompa-pa band started playing and the Canadian table, led by Bill and his wife got up and led a conga dance line, much to the surprise of the other delegates."

"When briefing him on a new safety issue the department was working on (usually during his lunch time), his exceptionally quick grasp of new issues meant that he was telling me how to solve the problem by the time I left his office."

"I do not know whether Bill was involved with NPD but he certainly was with Douglas Point and every Ontario Hydro plant after it. He probably had more impact than any other person on the design and construction of plants in Ontario."

"The major safety difference in the design of Douglas Point from the prototype NPD 2 was the addition of a designated "containment building". This resulted in many questions by the RSAC, especially about safety of the D. Pt. operating staff. In most cases Bill was able to propose changes acceptable to Wilson and to the RSAC..... Before Douglas Point started up Ontario Hydro proposed building "full scale" plants of 500 MWe (compared to the D. Pt 200 MWe) at a site they owned about 25 km east of the limits of the City of Toronto. The RSAC quickly took the positon that the Douglas Point containment design was not adequate..... Bill, who had moved back to OH, came up with the concept of attaching a "vacuum building" to the containment buildings..... The members of the RSAC were intrigued with the idea and encouraged OH to pursue it. This resulted in OH doing many variations of the design of connecting the reactor buildings to the "vacuum building" and many analyses, which Bill oversaw."

"William Gordon Morison was an exceptional person and a very competent engineer. He was in my top ten of mentors."

"Bill was immensely proud of what Ontario Hydro and AECL had done with the development of the CANDU reactor. He was proud of the technical achievements that had been made and of the quality of the staff designing and operating them, and was highly supportive of passing along new information from their most recent studies or experimental support to others in the nuclear industry."

"He was the Giant in the Ontario nuclear power program....A major inspiration for me and many others, and always supported my requests for international participation.

On the way home, during ongoing discussion about Bill's neutrino hypotheses, we saw a beautiful double rainbow. I foolishly and somewhat facetiously said to Bill, that it probably had something to do with neutrinos! He calmly said yes it has! A day later (September 28, 2006), he sent me a copy of his neutrino document in which he departs from conventional science, and a covering letter in his usual self-effacing style which I cherish:"

"... a very great man in a great company"

"Bill was my mentor, and the Father of CANDU system, and designer of the negative pressure Containment system."

Note from the Editor:

This memoriam was prepared by Hugh Irvine, Dan Meneley, Allan Brown, and John Luxat. Bill Morrison was too big to be remembered by a single person. In addition, the following people provided commentary and remembrances:

Ric Fluke (OH); Elgin Horton (OH); Bob Henry (Consultant); Walter Lee (OH); Vern Austman (OH); Ravi Ravishankar (OH); Jim Stebbing (OH); Ziggy Domaratski (AECB/CNSC); Fred Boyd (AECB); Jon Jennekens (AECB/CNSC); Tom Drolet (OH); Nabila Yousef (OH); Gary Vivian (OH).

Globe and Mail

Tuesday January 17, 2017

WILLIAM 'BILL' GORDON MORISON 1926-2016 passed away peacefully at home in Vancouver on Tuesday, December 27th at the age of 90. He joins his wife Ruth who passed away in 2008 and his daughter Cathy who passed away in 2012. Bill is survived by two sons Kip and Don, his brothers Doug and Bob, and his sister Doris. He was an amazing husband and father and will be missed and remembered by many.

Bill's wishes were to be cremated without a service. Memorial donations may be made to the Alzheimer Society of Canada.

CNA February Conference

Government Ministers United in Supporting Canadian Nuclear Power

By COLIN HUNT

It is perhaps unusual for elected officials to be strongly in support of nuclear power as a matter of public record, but such was indeed the case at the 2017 Canadian Nuclear Association Annual Conference in February.

"Nuclear energy has to be part of this equation because it already accounts for about 16 percent of Canada's electricity supply, and there is simply no reason why nuclear energy can't claim a larger share of our electricity mix. I don't know the last time you had a Minister of Natural Resources saying that, but I say it with confidence in you," stated Jim Carr, Minister of Natural Resources.

The Minister noted that Canada's nuclear industry was at the intersection of a number of the federal government's policy priorities: climate change, clean energy, green infrastructure, sustainable growth, and good jobs. Mr. Carr made it clear that the federal government views Canada's nuclear industry as advanced technology, not just in providing energy but also making strong contributions in health care, food safety and materials engineering.

Mr. Carr noted the strong investment being made in Ontario's electricity infrastructure. He also observed that Canadian-designed CANDU reactors are operating in seven countries around the world, and that Canada is the world's second largest producer and exporter of uranium. He was particularly upbeat about the new research facility, the Harriet Brooks Laboratory, at Chalk River.

With respect to the growth of new nuclear energy in Canada, Mr. Carr acknowledged that electricity infrastructure was the domain of provincial governments.

"That's where you come in, Mr. Carr said. "This is your chance to bring the provinces and territories on board by demonstrating how nuclear energy can help Canada to meet its climate change goals."

Kim Rudd, Parliamentary Secretary to the Minister of Natural Resources.

Mr. Carr made specific reference to Ontario's nuclear refurbishment program as an example of how public-private partnerships can further the development of Canada's nuclear industry.

"Our government gets it," Mr.Carr concluded. "We see Canada's nuclear industry for what it is: a strategic asset, a leader driver of innovation and, most of all, an important part of Canada's growing clean energy mix. You have the expertise, the technology and the supply chain."

Natural Resources Minister Jim Carr

Ontario Energy Minister Glen Thibeault.

Mr. Carr was far from alone among elected officials in his views. Kim Rudd, Parliamentary Secretary to the Minister of Natural Resources, noted that for the past year she has been involved in a large number of international meetings regarding nuclear power.

"Without exception, Canada has a very high international reputation around the world," Ms. Rudd stated.

These sentiments were echoed by Ontario Energy Minister Glenn Thibeault. In his remarks to the conference, he noted that Ontario has been the centre of Canadian nuclear innovation for more than 60 years and that this drive for advanced technology would continue.

"Our government is committed to innovation and jobs in Canada and Ontario," the Minister stated, "and our future lies in relying on export-ready high technology industry".

The Minister credited nuclear power with a large role in eliminating coal-fired power generation in the province and providing a large contribution to clean air. He observed with satisfaction that Ontario's latest refurbishment program at Darlington Unit 2 was ahead of schedule. He noted that the Ontario government was strongly interested in seeing the growth of Canadian nuclear technology such as CANDU both within Canada and around the world.

"Nuclear energy is an affordable, emission-free source of electricity," Mr. Thibeault said, "And we have the nuclear talent, energy and expertise to make it grow."

CNA February Conference

Utility Leaders Proud of Start to Refurbishment Programs

by COLIN HUNT

OPG President Jeff Lyash, Bruce Power President Mike Renchek.

Canada's nuclear utility leaders expressed strong confidence in the outcomes of their refurbishment programs and the Canadian Nuclear Association's (CNA) Annual Conference in Ottawa in February.

Ontario Power Generation (OPG) President and CEO Jeff Lyash expressed satisfaction with the commencement of the refurbishment of Darlington Unit 2. He noted that removal of fuel from the 480 fuel channels and other work to get the reactor in condition for refurbishment had been completed ahead of schedule.

"In my experience large projects often end as they start so we're very pleased with this good beginning," Mr. Lyash said. "That said, we view the refurbishment as a marathon, we know we have a long road ahead and we're committed to the success of this project and to the success of the Bruce Power refurbishment."

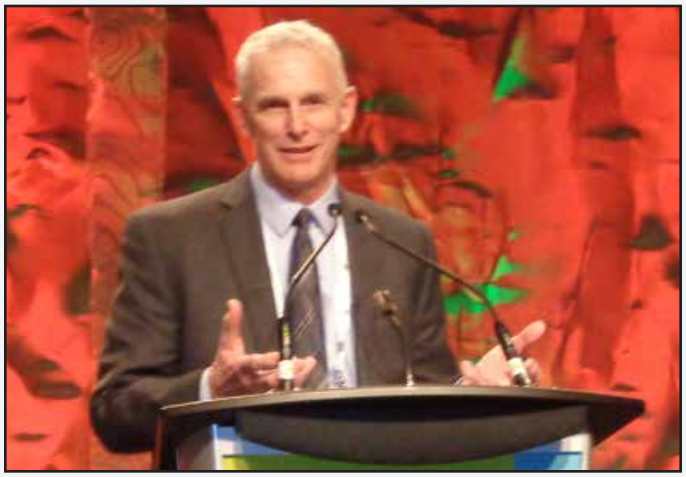
According to Mr. Lyash, the Conference Board of Canada has stated that the refurbishment of Darlington and its additional 30 years of service will add $89 billion to Ontario's GDP and create employment by 14,200 jobs per year. He also noted that for the first time the two largest infrastructure projects in Canada were OPG's refurbishment of Darlington and Bruce Power's refurbishment of six reactors at the Bruce nuclear power station.

Mr. Lyash also noted the ongoing importance of the Pickering nuclear station. Providing 14 per cent of Ontario's electricity, he indicated that continuing operation of Pickering to 2024 was vital to refurbishment plans in Ontario.

Michael Renchek, President and CEO of Bruce Power, was similarly upbeat about Ontario's nuclear future. He observed that Bruce Power invested $430 million in its reactors last year, and that it would do so again this year and in each of the years to come.

"Bruce Power has a future to 2064," Mr. Renchek proclaimed. "The station will be operating for another fifty years."

Mr. Renchek noted that Bruce Power started working on its refurbishment program last year, with major component replacement to come in 2020. At this point, Bruce Power has already added 24 years to the life of the station.



CNA Chairman Glenn Jager opens the conference.

The value of investment in Bruce Power's reactors is enormous, according to Mr. Renchek. The station contains more than 6 GW of capacity, producing electricity at 6.6 cents/kWh. That compares favourably with costs from other sources of hydro, 6 cents; wind, 14 cents; gas, 17 cents; and solar, 48 cents. He noted that out to 2064, Bruce Power will have invested $180 billion over Bruce Power's half-century, and avoided $64 billion in cap and trade costs.

"We produce 30 per cent of Ontario's electricity at 30 per cent below the average residential price," Mr. Renchek said.

He also noted that the beginning of the nuclear restoration program at Bruce has been accompanied by a dramatic, visible reduction in air pollution. In 2005, Toronto had 23 smog alert days. In 2016, there were zero.

In calling Mr. Lyash up onto the stage, Mr. Renchek made it clear that Ontario's nuclear operators were working together in strong collaboration.

Speaking at the opening of the conference, CNA Chairman Officer Glenn Jager gave conference delegates a longer and global view of the role that nuclear power must play.

"Future electricity supply must rise by about ten-fold if it is to replace other energy applications now relying on fossil fuel," Mr. Jager said. In Mr. Jager's view, this means that the long term development of nuclear power as a primary energy source has barely begun.

Michael Binder, President of the Canadian Nuclear Safety Commission (CNSC) was also a featured speaker at the conference. Mr. Binder noted that there had been growing interest in the development of small modular reactors over the past year. He stated that the CNSC had advantages over regulatory authorities in other nations.

"We don't follow the US model of prescriptive regulation," Mr. Binder said. He noted that performance based regulation was particularly appropriate, observing that rules necessary for one kind of technology may not be appropriate for another. He also made a clear distinction between some rules which must be prescriptive based, such as those for issues like non-proliferation, and those which are safety-related and relative to a particular technology. He made it clear that the CNSC will not be the bottleneck of new nuclear innovation, and that the purpose of a regulator was to implement government policy, not to create it.

"It is never a wise idea to have policy formation and safety regulation in the same body," Mr. Binder said.

One of the most interesting sessions was a panel on small modular reactors, chaired by Dr. Neil Alexander. Panelists included Rory O'Sullivan of Maltex Energy, Hugh MacDiarmid of Terrestrial Energy Inc., and Sean Donnelly of U-Battery. The three represented companies developing different types and sizes of SMRs.

Mr. O'Sullivan tracked through the development of nuclear power since the 1960s. He observed that there had been a huge jump in installed costs for new reactors in 1983, and another very large increase in installed costs in the 2000s. He stated that it was his view that small modular reactors were one way to reduce nuclear installed costs.

Mr. MacDiarmid noted that all modern SMR designs were based principally on higher operating temperatures producing greater thermal efficiencies. For example, molten salt reactors would work at 600 degrees Celsius as opposed to 300 degrees for water-based reactors. He also noted that thus far the nuclear industry had been constrained to large utility applications only because of the large size of the reactors.

Mr. Donnelly observed that U-Battery was developing a high temperature gas reactor to work as very small units, approximately 4 MW of power. Unlike the larger SMRs, U-Battery's project was for off-grid applications for either industry or remote sites. He indicated that his company was looking at deployment in Canada, Poland and the United Kingdom.

The CNA Annual Conference attracted over 750 delegates to Ottawa this year, with 27 sponsoring companies and 20 additional exhibitors.

SMR Panel Neil Alexander, Rory O'Sullivan, Hugh MacDiarmid, Sean Donnelly

Nuclear Science Week across Canada, 2016

by J. M. K. C. DONEV,[1] J. U. HANANIA,[1] K. STENHOUSE,[1] J. E. WILLIAMS,[1] M. J. BOOTSMA[1]

The second year of Canada's involvement in Nuclear Science Week was a success. Events were held across Canada (Alberta, Saskatchewan and Ontario) and were universally well received. Nuclear Science Week seeks to coordinate activities getting people talking about nuclear science for a week; this year in Canada, Nuclear Science Week was from October 15th through 22nd.The events were fun and informative; there is wide agreement that we should do this again. If we start planning now, every CNS branch in Canada could have an event promoting public interest for nuclear science and technology in the fall of 2017.

This collaboration between the Canadian Institute for Nuclear Physics (CINP), the Fedoruk Centre, University of Regina, University of Saskatchewan, University of Guelph, the University of Calgary, the Canadian Nuclear Society and the world wide Nuclear Science Week committee should be encouraged and expanded. Please see below for specifics on what we have done so far as a template for Canada-wide participation in 2017.

The event in Calgary was quite successful. We had 100-120 members of the public come for four presentations at the Rothney Astrophysical Observatory. Dr. Wendy Smith presented on how nuclear science is fighting cancer. Dr. Ann-Lise Norman presented on how the atmosphere is studied by using various stable isotopes. Dr. Dave Hobill presented on how nuclear physics makes stars shine. Dr. Jason Donev presented with several students on how the chart of the nuclides tells us about nuclei.

Additionally, we had three popular posters from undergraduate students from the energy education research group. One was talking about the three dimensional chart of the nuclides. The second was talking about educating the public about energy in general and nuclear in particular using a website. A third student presented on making radioactive samples from charging a common balloon and looking at the spectrum that came from the radon daughter products. A group of students showed off common sources of naturally occurring radioactive material and a nuclear fuel bundle. Another group of students showed off the telescopes.

The students, presenters and public all had a great time. Even small children (between the ages of 5-10) were enthused. This was the second year in a row where this event was held at the Rothney Astrophysical Observatory to celebrate nuclear science week, and there was a request to do this again next year.

In Saskatchewan the Fedoruk Centre brought in Prof. Nicholas Priest in from the United Kingdom to give talks on low dose radiation in Saskatoon and Regina, both were quite successful. Dr. Priest gave a public talk, "Just How Dangerous is Low Dose Radiation?" as part of the Tox on Tap science pub series. This series is organized by graduate students at the University of Saskatchewan Toxicology Centre. The event was attended by ~110 people. Dr. Priest was also interviewed for Tox on Tap's first pre-talk community cable show.

In Regina, Prof. Priest gave a talk on the Semirad facility at Kazakhstan in the afternoon at the University of Regina, attended by about 35 people, mostly people from the Physics Department. In the evening, Prof. Priest also gave a talk on Low Doses of Radiation at a Pub. This event had ~30 members of the public. That facility, which we use for Science Pubs once a month, holds 50 people, so there is room for growth in the coming year.

In Ontario Dr. Liliana Caballero hosted "Nuclear Science Day" from 9:30 AM to noon, in the Science Complex Atrium at the University of Guelph.

The event was open to the general public and it aimed to offer a background of nuclear science achievements and showcase the work of nuclear researchers in Guelph. Six students presented posters on their current research. Dr. Caballero gave a public lecture discussing applications of nuclear physics to everyday life. This talk included radiation, the goals of modern nuclear physics and the research at the University of Guelph.

A highlight of this particular Nuclear Science Week event was a table on building a 3D version of the nuclear chart (up to Neon) with LEGOs. The initiative was borrowed from the Binding Blocks collaboration from the University of York in the UK.

30-40 people attended and all of them very involved in the activities. In the coming year when this event will be held a second time, the intention is to advertise with school boards to target more high school students.

This resounding success is encouraging. Seeing the public interested and engaged in learning about nuclear science and technology is something that the entire nuclear industry should participate in. Talking with people who are curious and enthusiastic about nuclear science and technology is invigorating. The participants of Nuclear Science Week suggest that the CNS get every branch to do something for Nuclear Science Week 2017.

1 University of Calgary, Department of Physics and Astronomy, Energy Education Group

Enhancing Nuclear Learning

by M. CHATLANI, B. GAGNON[1]

As Ontario moves ahead with refurbishing 10 of its 18 nuclear reactors–an exciting period in Canada's long and successful nuclear history–the industry is also faced with a challenge that could affect its day-to-day activities: a rapidly aging workforce. A report that was published by the Canadian Nuclear Association in 2008 stated that around 38 percent of workers in the nuclear industry are above the age of 50 and approaching retirement age[1]. The resulting workforce replacement effort introduces nuclear newcomers of a new generation with different backgrounds and affinities. Major lifestyle differences between the two generations of workers result, among other things, in different learning habits and needs for this new breed of learners. Interactivity, high visual content and quick access to information are now necessary to achieve a high level of retention.

To enhance existing training programs [or to support the establishment of new training programs for newcomer countries], L3 MAPPS has devised learning technologies centered on two main principles:

1. Seeing is understanding, and
2. Interacting helps remember.

L3 MAPPS has coupled computer visualizations with high-fidelity simulation to bring real-time, simulation-driven animated components and systems allowing immersive and participatory, individual or classroom learning.

New Generation, New Needs

Workforce replacement introduces nuclear newcomers of a new generation with different backgrounds and affinities than its predecessors. New generation workers entering the industry have been raised with modern digital technology integrated in everyday life. The wide-scale exposure to more and more realistic video games, readily available computers, tablets, smart phones and the internet has shaped the habits and minds of the Y (born 1980-1990) and Z (born 1990 onwards) generations. These generations are "digital natives", people who are "native speakers" of the digital language and are extremely technology savvy, as opposed to older generations or "digital immigrants" who were not born in the digital world but have adopted many or most aspects of the new technology era [2].

These fundamental lifestyle differences result, among other things, in different learning habits and needs for this new breed of learners. Some of these habits can be summarized [3] as:

- They are highly visual learners preferring to process pictures, sounds, and video rather than text.
- They are experiential learners who learn by discovery rather than being "told". They like to interact with content to explore and draw their own conclusions. Simulations, games, and role playing allow them to learn by "being there" and also to enjoy themselves.
- They have shorter attention spans, so prefer bite-sized chunks of content.

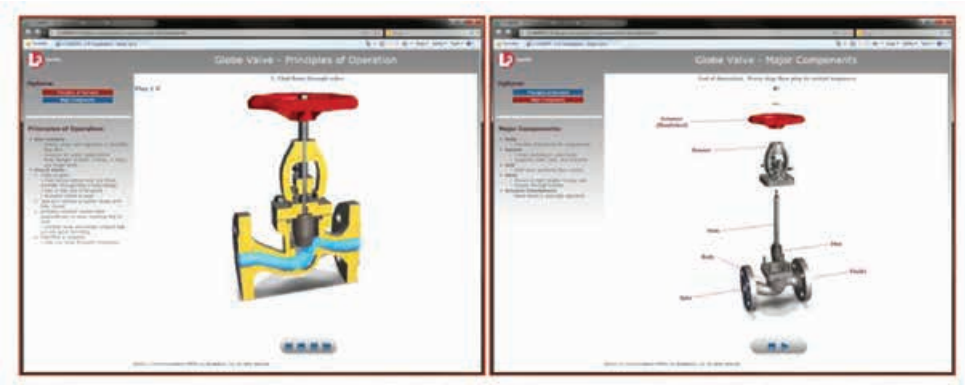
2-D/3-D Visualizations and Simulation to Enhance Nuclear Training Programs

L3 MAPPS has devised several learning technologies that address these issues and challenges which provide for the use of "practice by doing" earlier in the conventional training cycle. These technologies are Learning Modules, System Knowledge Modules and Learning Simulators. L3 MAPPS has coupled 2-D and 3-D computer visualizations with high-fidelity simulation to bring real-time, simulation-driven animated components and systems allowing immersive and participatory, individual or classroom learning. With this innovative approach to training, L3 MAPPS is making it possible to increase student retention rates by making the learning experience much more interactive and efficient.

Learning Modules for Generic Fundamentals

With Learning Modules, students can explore how plant equipment is built and how it works. The 3-D external casings can be dissolved. Components can be rotated and zoomed to display their inner workings. Not only are the components identified, but the physical operation is animated, eliminating the difficult task of trying to mentally picture equipment operation from traditional, static 2-D representations.

1 L3MAPPS, Montreal, Quebec, Canada

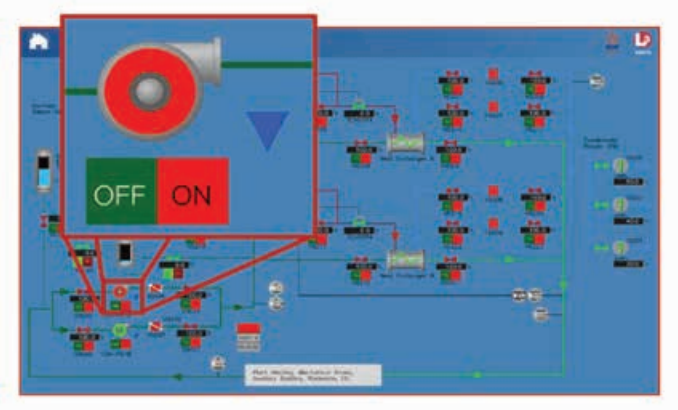


Globe Valve Learning Module

Learning Modules run within most popular web browsers such as Windows Internet Explorer or Google Chrome, removing the need to purchase and learn new enabling software. This makes access to Learning Modules both easy and flexible. The modules can be installed locally on the computer used or on a central server that can be accessed by all teachers and students. Access can be given directly to the modules or by adding simple web links to the existing courseware such as PDF documents, PowerPoint presentations, etc. The user interface is very simple, clean and intuitive, removing technological barriers between the students and better learning.

System Knowledge Modules

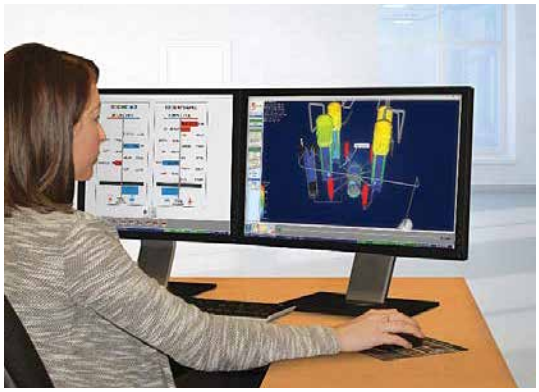
With System Knowledge Modules, students can explore how systems are built and how they work. The system graphical representation (i.e. active diagram) has the look-and-feel of a plant drawing (e.g. piping and instrumentation diagram). A high-fidelity simulation of the specific system runs behind the scene to calculate all the system parameters (e.g. pressures, temperatures, flows, etc.) displayed on the system active diagram. System Knowledge Modules are fully interactive allowing students to operate plant equipment and monitor the associated system's real-time response. Examples of System Knowledge Modules include plant heating/cooling systems, level control loops, pump and motor breaker logic, etc.



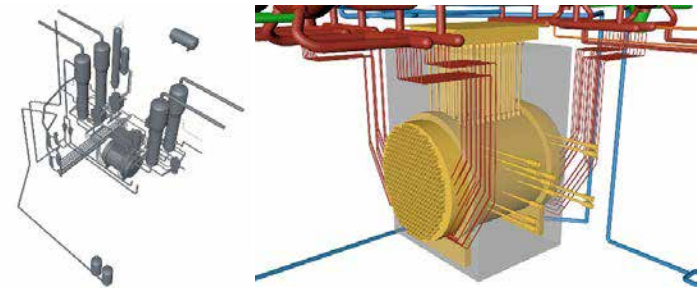
Plant Heating System Knowledge Module

Learning Simulators

Learning Simulators have been designed to assist teaching and learning of major plant transients and the associated power plant systems and behavior, by coupling 2-D and 3-D interactive graphic visualizations with high-fidelity simulation. Focused primarily on the Nuclear Steam Supply System (NSSS), the goal is to increase the student's understanding and retention of system behavior and major plant events. Learning Simulators can be set up as standalone scenario-based student devices or can also be attached to operators' and colleges' existing training simulators to introduce a new level of situational awareness which has not been attained yet with most operator training simulators to date.



4-Loop PWR Learning Simulator



CANDU plant model being developed for Learning Simulator application

Possible Learning Environments

The first view presented by the Learning Simulator is that of the containment building, populated to scale with the major components of the reactor, reactor coolant system and the emergency core cooling systems. This 3-D view helps the student understand the system's spatial orientation and geometry. Students can even look inside the equipment to see equipment internals and can turn on and off labels naming the various equipment or components. The same 3-D models are then used to show and explain the equipment and system's behavior with the help of high-fidelity simulation. The Learning Simulator takes simulator-calculated nodal properties such as temperature, pressure and void fraction, and displays them within 3-D models of the plant piping and equipment using color maps. As system properties change, colors change accordingly, translating simulator data into colors on-the-fly. Dynamic, simulator-driven 3-D visualization provides a new way of looking at a system's behavior by presenting a comprehensive graphical representation of the complete system's state. Capitalizing on the "seeing is understanding" principle, the Learning Simulator converts thousands of data points into a simple, easy-to-understand dynamic image. The Learning Simulator's models differ from ordinary static images or video animations by providing control to the student, who can interact with them at will by panning, zooming and rotating the models, or choosing what to look at, such as which physical property is displayed, focusing on particular parts of the system, etc.

While the dynamic 3-D models present a dynamic yet instantaneous snapshot of the system's properties, the Learning Simulator's Analysis Screen completes the picture by providing additional engineering information on a 2-D representation of the system, a mass and energy balance bar-graphs as well as pre-defined or user-defined plots to understand the evolution of the system's properties and behavior.

Learning Environments

The proposed learning technologies are well suited for classroom training, individual learning, and/or team building using desktop or tablet PCs with or without touch technology.

Conclusion

As the Canadian nuclear power industry workforce ages and retires, a new generation of workers needs to be educated and trained. With this new audience, existing training methods and support tools should be enhanced to facilitate learning and to achieve high retention rates. The combination of interactive visualizations and simulation provides a modern medium that will not only fill the students' need for technology and engagement–both in the classroom and outside the classroom–but also provide rich and valuable information that was difficult to convey in the first place. L3 MAPPS believes that these new learning technologies will help the nuclear power industry to train a knowledgeable workforce more efficiently.

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Evidence That Lifelong Low Dose-Rates of Ionizing Radiation Increase Lifespan in Long- and Short-Lived Dogs

by JERRY M. CUTTLER[1], LUDWIG E. FEINENDEGEN[2] and YEHOSHUA SOCOL[3]

[The following paper, submitted to the Bulletin by the author, has been published in **Dose Response: An International Journal,** *January-March 2017:1-6.]*

Abstract

After the 1956 radiation scare to stop weapons testing, studies focused on cancer induction by low-level radiation. Concern has shifted to protecting "radiation-sensitive individuals." Since longevity is a measure of health impact, this analysis reexamined data to compare the effect of dose-rate on the lifespans of short-lived (5% and 10% mortality) dogs and on the lifespans of dogs at 50% mortality. The data came from 2 large-scale studies. One exposed 10 groups to different dose-rates of γ-radiation; the other, 8 groups to different lung burdens of α-emitting plutonium particulates. Reexamination indicated that normalized lifespans increased more for short-lived dogs than for average dogs, when radiation was moderately above background. This was apparent by interpolating between the lifespans of non-irradiated dogs and exposed dogs. Optimum lifespan increase appeared at 50 mGy/year. The threshold for harm (decreased lifespan) was 700 mGy/year for 50% mortality dogs and 1100 mGy/year for short-lived dogs. For inhaled plutonium, longevity was remarkably increased for short-lived dogs below the threshold for harm. Short-lived dogs show more radiosensitivity than average dogs, and they benefit more from low radiation. If dogs model humans, this evidence would support a change to radiation protection policy. Maintaining exposures "as low as reasonably achievable" (ALARA) appears questionable.

Keywords: ionizing radiation, beagle dogs, individual sensitivity, longevity benefit, harmful thresholds, adaptive protection

Introduction

Many studies have been carried out on effects of ionizing radiation on organisms over the past 120 years. The overall effects are well known at high doses. At high and low doses, the detailed cell response mechanisms are complicated and may involve all levels of biological organization. About 75% of the human body is water, and a principal effect of radiation is the creation of reactive oxygen species (ROS), including hydrogen peroxide. They are a double-edged sword. Depending on their concentrations, they may cause damage or signaling in terms of stress responses.[1] Moreover, ROS are produced abundantly and constantly by aerobic metabolism.[2] Most studies focus on harmful effects, mainly risks of cancer, because of the low-level radiation scare that was introduced in 1956 to stop nuclear weapons testing and proliferation.[3,4] The government regulators, world-wide, accepted the recommendation of the U.S. National Academy of Sciences in 1956 that the risk of radiation-induced genetic mutations be assessed using a linear no-threshold (LNT) model.[5] "Radiation exposure has never been demonstrated to cause hereditary effects in human populations"[6] ; however, there is evidence for x-rays and nuclear radiations to cause mutations in cells, which may contribute to the risk of cancer.

Studies on experimental living systems and on humans have shown, depending on the individual genome, that low doses of radiation up-regulate many biological protective mechanisms, which also operate against nonradiogenic toxins and produce beneficial effects, including a lower risk of cancer.[7] Still, most regulators uniquely employ the LNT model to estimate the risk of radiation-induced cancer deaths. After considering the health consequences of the precautionary evacuations following the 2011 nuclear accident in Japan and the impacts of the radiation scare on the economy, it has become obvious that society is paying a very high price because of public fear of low-dose radiation.[8]

For more than a century, extensive studies have been carried out on the effects of radiation, which demonstrate that harmful effects, such as radiation illness, may arise after exposures above known threshold dose levels, whereas a range of beneficial effects may be observed following low-dose exposures.[7,9,10,11] Although there appears to be an awareness amongst the prominent leaders of the radiation protection establishment that radiation protection policy contradicts this biological evidence, there is a very broad consensus among them that it is impossible to attribute health effects to low radiation exposures, namely to exposures similar

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3 Falcon Analytics, Karnei Shomron, Israel

to the wide spectrum of background levels.[12] This opinion does not consider the recent progress in biological research on the mechanisms that underlay the fact that living organisms are "complex adaptive systems."[13]

In radiation protection, the words "health effects" imply radiation-induced fatal cancer incidence that is calculated using the LNT model. The "health effects" of background radiation are small when compared with the average incidence of cancer deaths (less than 1 in 40 deaths) and, therefore, cannot be demonstrated due to large statistical uncertainties.

DNA alterations (damage) occur at a very high rate due to endogenous causes.[2] To stay alive in a hard-to-avoid environment of multiple toxic impacts, all organisms have powerful protective mechanisms that prevent, repair or remove damage in and to cells. Surviving cells continue to accumulate endogenous and exogenous mutations and may become cancer cells. These may be detected and destroyed by the immune system to prevent the development and spread of cancer. A weakened or impaired immune system is usually a precondition for cancer mortality.[14] Since low doses of radiation stimulate many protective systems, including the immune system, it is very unlikely that low level radiation causes more damage than benefit. Indeed, as damage propagation to molecules and cells from low doses can hardly be observed, protective mechanisms can be seen readily and be quantified.

Regulatory disregard of the biological evidence of beneficial health effects leaves lingering fear and uncertainty about cancer risks that sustain the risk assessment community. It restricts many medical applications of x-rays in diagnostic imaging and low-dose therapy. It blocks social acceptance of the nuclear energy option through fear of exposure to radioactive materials from power plants and waste management sites. When people increasingly question whether low levels or low doses of radiation are really harmful, protection practitioners argue that "radiation-sensitive individuals" exist who are more vulnerable than average people to potential "health effects" and must be protected.[15] This concern about protecting sensitive individuals and the suggestion that longevity may be the most appropriate measure of the effect of radiation on health[16,17] led to this examination of the effect of dose rate on the lifespans of dogs.

Analysis of 2 studies on beagle dogs

To assess the effect of radiation level on more sensitive individuals, the authors reexamined data on the health effects of long-term irradiations in 2 large scale studies on groups of beagle dogs. One exposed the dogs to whole-body cobalt-60 γ-radiation. The other evaluated dogs whose lungs were exposed to α-particle radiation from plutonium. Each group of dogs received a different dose rate. Beagle dogs are assumed to model humans well and have been the preferred choice for many studies by the U.S. Department of Energy and its predecessor agencies since the 1950s.[18]

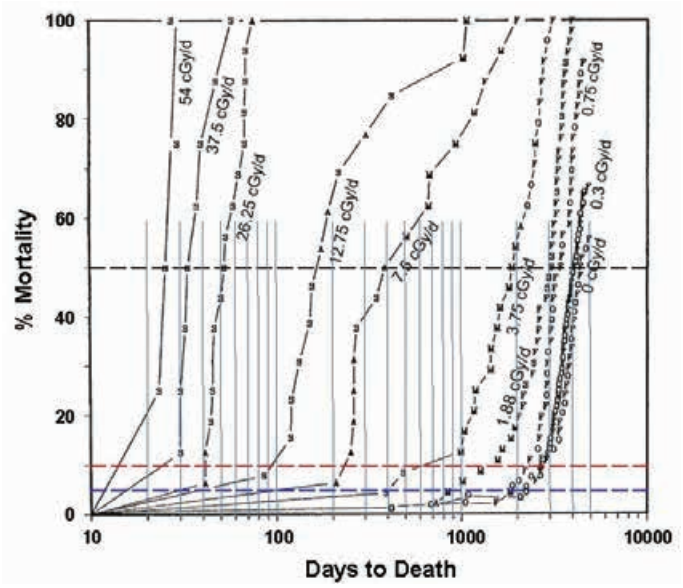

Figure 1. Mortality curves of dogs subjected to cobalt-60 γ-irradiation at different dose rates (Figure 3).[23] The vertical lines were added to facilitate reading of the lifespan at the intersection of each mortality level (50%, 10% and 5%) with the mortality curve of each group of dogs.

These studies had been reviewed previously to determine the dependence of the lifespan of 50% mortality dogs on dose rate.[9,19] Analysis of the data of the first study suggested an increase in the lifespan of dogs exposed to 50 mGy of γ-radiation per year, compared to the control dogs. Analysis of the data of the second study suggested an increase in longevity for dogs with an initial plutonium lung burden of 0.1 kBq/kg, compared to the control dogs.

These are very credible studies, carefully carried out by qualified and experienced scientists who bred the dogs and controlled all confounding factors. Particular attention was given to dosimetry. In the cobalt 60 study, all factors contributing to the dose rate and total dose were normalized in the irradiation field by migrating the dogs through all positions and orientations with respect to the irradiation source.[18,20]

Chronic γ-irradiation

The methodology of this study is well described by Grahn and Fritz[21] and by Fritz et al[22]. Using the data in Figure 1,[23] the lifespans of dogs at 5%, 10% and 50% mortality in the control group (background dose rate) were compared with the lifespans of the 5%, 10% and 50% mortality dogs in each dose rate group. The

Table 1. Lifespans of dogs versus radiation dose rate (Adapted from data in Fliedner et al.)[23]

		Lifespan (days)			Lifespan (normalized)		
Dose Rate (cGy/d)	Dose Rate (mGy/y)	50% mortality	10% mortality	5% mortality	50% mortality	10% mortality	5% mortality
background	2.4×10^0	4300	2700	2150	1.00	1.00	1.00
0.3	1.1×10^3	4050	2700	2150	0.94	1.00	1.00
0.75	2.7×10^3	3300	2200	1800	0.77	0.82	0.84
1.88	6.9×10^3	3000	1300	850	0.70	0.48	0.386
3.75	1.4×10^4	1900	600	400	0.44	0.222	0.182
7.5	2.7×10^4	400	220	95	0.093	0.081	0.043
12.75	4.7×10^4	150	91	40	0.035	0.034	0.0182
26.25	9.6×10^4	51	40	30	0.012	0.0148	0.0136
37.5	1.4×10^5	32	23	15	0.0074	0.0085	0.0068
54	2.0×10^5	24	13	11	0.0056	0.0048	0.0050

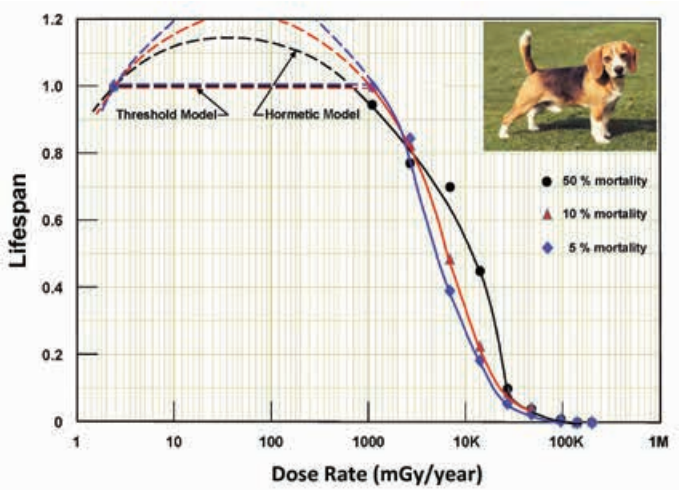

Figure 2. Lifespans of groups of dogs at different cobalt-60 γ-radiation dose rates. The black dot is the normalized lifespan of the 50% mortality dog in each group. The red triangle and the blue diamond are the normalized lifespans of 10% and 5% mortality dogs. Adapted data from Fliedner et al.[23]

intersection lifespans, tabulated against the dose rate, are presented in Table 1, and the normalized lifespans, plotted against the dose rate, are presented in Figure 2.

Unfortunately, the design of this study did not include groups of dogs exposed to dose rates between background and 0.3 cGy/d. A group exposed to a dose rate of about 0.015 cGy/d (55 mGy/y) would have provided data to interpolate lifespans between the natural background level and the threshold dose rates at 700-1100 mGy/y. Lacking this data, interpolations based on both threshold and hormetic dose-response models are shown as dashed lines.

The dashed hormetic lines, drawn with the same curvature as the solid lines, very likely model the true response of longevity versus dose rate over this factor of 300 to 400 range. This judgment is based on the Calabrese and Baldwin review[17] of many animal model studies on the effect on longevity of long-term, whole-body exposure to low dose rates of γ-rays. The magnitude of the increase in median lifespan ranged from 10 to 30%. In addition, there is extensive evidence and radiobiology endorsing the hormetic model for this interpolation.[7,24,25,26]

It was anticipated that the "short-lived" 5% and 10% mortality dogs would be more sensitive, adversely, to the effects of low dose-rate radiation–that their lives would be significantly shortened. On the contrary, Figure 2 suggests that their dose-rate thresholds for lifespan shortening are higher than that of the 50% mortality dogs. The lifespans of the 50% mortality dogs begin to decrease above a threshold of about 700 mGy per year, whereas the lifespans of the more radiation-sensitive (5 and 10% mortality) dogs begin to decrease above thresholds of about 1100 mGy per year. Their lifespans drop more steeply with increasing dose rate, indicating their greater sensitivity to radiation. The fitted lines are quite close to the data points.

The hormetic interpolations suggest that the optimum dose rate for longevity is about 50 mGy per year for all mortality levels. The lifespan increase is about 15% for 50% mortality dogs and much greater for the more radiation-sensitive dogs.

Chronic α-irradiation of lungs

The paper by Muggenburg et al[27] describes in detail their study on 216 beagle dogs, which were exposed at 12-15 months of age by inhalation and pulmonary deposition of 7 graded activity levels of insoluble plutonium dioxide aerosols. The levels ranged from 0.16 to 29 kBq/kg initial lung burden. There were 36

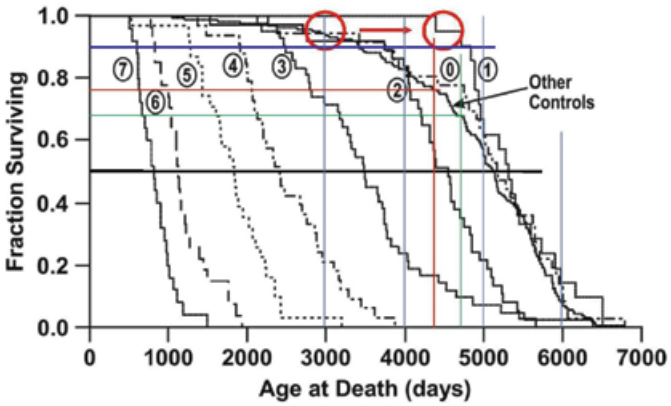

Figure 3. Fraction surviving curves of dogs with different lung burdens of inhaled plutonium-dioxide aerosols (Figure 4).[27] The red circles indicate that the shorter lived control dogs (5% mortality level) have a lifespan of about 3000 days, while the dogs in group 1 (initial plutonium lung burden of 0.16 kBq/kg) have a lifespan of about 4500 days, 50% longer. Also shown are the 10 and 50% mortality levels.

control dogs, 18 male and 18 female (exposure level 0). The data on the observed carcinogenic and non-carcinogenic effects are analyzed and discussed.

Figure 3 above, from the article by Muggenburg et al[27], presents the survival curves. They combined data from all three aerosol particle sizes within each exposure level. They also included survival curves for the 36 study controls and the 142 "Other Controls" from other lifespan studies on the same breed of dogs.

This analysis determined the age at death (lifespan) of the dogs at 5, 10 and 50% mortality in the controls and in the 7 exposed groups from the intersections of the survival curves with the mortality levels, as shown in Figure 3. The results are shown in Table 2. Normalized lifespan versus plutonium lung burden (dose rate) are plotted in Figure 4. Lines were drawn that fit quite closely to the data points.

It was anticipated that short-lived dogs at 5 and 10% mortality would be more sensitive, adversely, to the effects of α-radiation in their lungs–that their lives would be significantly shortened. On the contrary, Figure 4 suggests that their thresholds for lifespan reduction are significantly higher than those of the 50% mortality dogs, that is, about 0.65 kBq/kg versus 0.25 kBq/kg.

Dashed lines were drawn to interpolate the lifespans from the fitted lines to 0 plutonium burden. The lifespan lines suggest increased longevity when the lung burden is between 0 and the thresholds for harm (reduced lifespan). The more radiation-sensitive dogs experience a greater benefit than less sensitive dogs. The optimum lung burden appears to be about 0.1 kBq/kg, for all mortality levels.

These data again suggest that control dogs (no plutonium) at 5% mortality are much more sensitive to α-radiation in their lungs than are 50% mortality dogs. Figure 3 and Table 2 indicate that group-1 dogs at the 5% mortality level have a remarkably long lifespan. They live about 50% longer than the control dog at the 5% mortality level, 4500 days for group-1 versus 3000 days for the control dog.

Assessing the statistical significance of the group-1 longevity data, it is apparent that the first of the group-1 dogs died at an age of about 4400 days. This means that none of these 21 dogs died before that age. Examining the survival curve of the large "Other Controls" group of 142 dogs, 4400 days corresponds to a survival fraction of 0.77, as shown by the red lines in Figure 3. The probability that all of the 21 dogs will survive this long, each having a probability of 0.77, is 0.77^{21}. This amounts to about 0.004. The corresponding *P* value is 0.4%. That means that the probability of a statistical fluctuation leading to the actual result of all the group-1 dogs living longer than 4400 days is 0.4%. In medicine, a confidence level of 5% or 1% is generally accepted as significant, so a *P* value of 0.4% is very significant.

Figure 3 indicates that the longevity benefit from lung irradiation is smaller for the less sensitive dogs at the 10% mortality level. The longevity of the control dogs at the 10% mortality level is about 3600 days; the longevity of the group-1 dogs at the 10% mortality level is about 4800 days, an apparent increase of about 33%. Assessing the statistical significance, the second dog of the group 1 dogs died at an age of about 4720 days. In the Other Controls group, 4720 days corresponds to a survival fraction of 0.68, as shown by the green lines in Figure 3, or a death probability of 0.32. The probability that, out of the 21 dogs, 0 or 1 will die (20 or 21 will survive), whereas individual survival is independent with probability 0.68, is given by the binomial distribution and is equal to $0.68^{21} + 21 \times 0.68^{20} \times 0.32 = 0.0033$. The corresponding *P* value is about 0.3%, which is also very significant.

The age at death of the Other Controls at a survival fraction of 0.5 (50% mortality) is about 5150 days. At this age, it is apparent from counting the steps that 8 of the 21 group-1 dogs died. Assuming that individual survival is independent for each dog with p = 0.5, the probability of 13 or more dogs surviving is given by the binomial distribution as about 19%. Therefore, the indication in Figure 4 that the group-1 dogs at 50% mortality may live about 5% longer than the control dog at 50% mortality is not significant.

It is interesting to note that the median lifespan (50% mortality) of the control dogs in the plutonium inhalation study, about 5150 days, is longer than median lifespan of the control dogs in the γ-irradiation study, about 4300 days. Different breeds of beagle dogs were apparently used in the 2 studies.

Table 2. Lifespans of dogs versus initial lung burden (ILB) inhaled at 12-15 months.

Group	Initial Lung Burden (kBq/kg)	Lifespan (days)			Lifespan (normalized)		
		50% mortality	10% mortality	5% mortality	50% mortality	10% mortality	5% mortality
Control	0	5150	3610	3000	1.00	1.00	1.00
1	0.16	5316	4760	4500	1.03	1.32	1.50
2	0.63	4526	3780	2910	0.88	1.05	0.97
3	1.6	3482	2500	2310	0.68	0.69	0.77
4	3.7	2421	1940	1500	0.47	0.54	0.50
5	6.4	1842	1280	1280	0.36	0.35	0.43
6	14	1122	840	810	0.22	0.23	0.27
7	29	807	625	530	0.16	0.17	0.18

(Adapted from data in Muggenburg et al.[27]) Cumulative lung dose for 10 kg dog (lung mass about 100 g) with ILB of 1 kBq at 1100 and 5000 days is about 0.5 and 1.2 Gy, respectively.

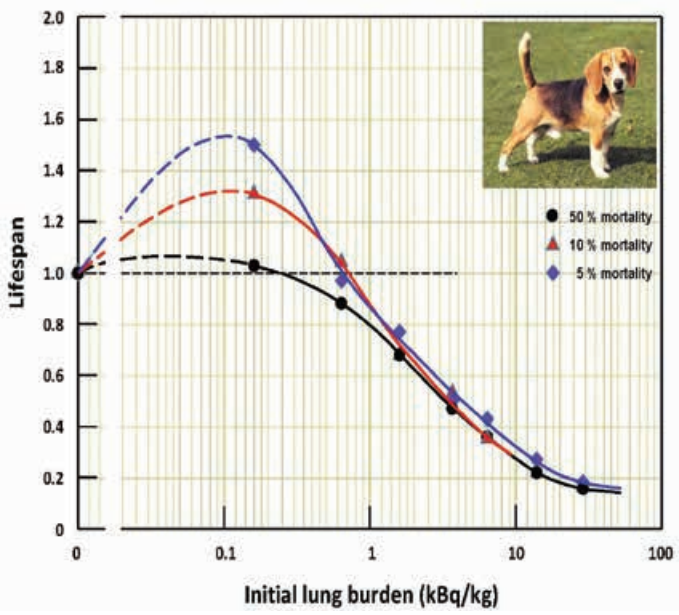

Figure 4. Lifespans of groups of dogs at different initial lung burdens of inhaled plutonium dioxide aerosols. The black dot is the lifespan of the 50% mortality dog of each group. The red triangle is the lifespan of the 10% mortality dog in each group, and the blue diamond is the lifespan of the 5% mortality dog in each group. Adapted from data in Muggenburg et al.[27]

A study on rats that inhaled plutonium-dioxide aerosols[28] has shown a threshold for lifespan reduction at a lung dose of about 10 Gy; lifespan increase for short-lived rats with a low lung dose was not apparent.

Discussion and Conclusions

This analysis of mortality/survival data in the 2 studies suggests that short-lived (5% and 10% mortality) dogs are more sensitive to radiation than are long-lived (50% mortality) dogs. These more radiation-sensitive dogs seem to receive the benefit of increased longevity from low-level radiation, instead of the presumed adverse health effect of decreased longevity. For the dogs who received low-level α-radiation in their lungs (group 1), the relative increases in the lifespans of the more radiation-sensitive dogs (about 50% and 33%) appear much greater than the relative increases in the lifespans of the less-sensitive dogs (about 5%).

This analysis suggests that the optimum gamma radiation level for beagle dogs is about 50 mGy per year, and the optimum initial plutonium lung burden is about 0.1 kBq/kg. A possible explanation of this observation is that more radiation-sensitive dogs are more receptive to low-dose, radiation-induced upregulation or stimulation of their adaptive protection systems than are the less sensitive, 50% mortality dogs.

The radiation threshold for onset of lifespan reduction appears to be higher for more sensitive dogs. The threshold for γ-radiation is about 700 mGy per year (50% mortality dogs); about 1100 mGy per year for the more sensitive dogs. For inhaled plutonium aerosols, the threshold for decreased longevity is about 0.25 kBq/kg (50% mortality dogs); about 0.65 kBq/kg for the more sensitive dogs.

The longevity of the more sensitive dogs appears to decline more steeply with rising dose rate as the γ dose-rate increases above the threshold for harm. Inhaled plutonium aerosols remain in the lungs, and the short-range α-radiation damages only nearby cells. It is very important to note that this very local exposure seems to affect the lifespan of the entire dog. Low-level radiation induces a significant increase in the longevity of the more sensitive dogs.

If beagles model humans, then these conclusions

would apply also to people, supporting the views of Siegel et al[29] that regulatory application of the LNT hypothesis and ALARA to protect radiosensitive people is misguided.

Recommendations

If dogs model humans, then one should expect that radiation-sensitive individuals would benefit more from exposures to low-level radiation than average humans. So protecting sensitive people from low-dose γ- or α-radiation would be inappropriate because it would deprive them of the health benefit of a longer life.

Protecting people against harm from high-level radiation is very important. Based on the results of this analysis, the threshold for increased mortality attributable to continuous exposure to γ-radiation appears to be about 700 mGy per year. Since beneficial health effects are likely below this level, the protection limit could be safely raised to at least 300 mGy per year, with no added risk.

Low-level exposure to inhaled α-emitters appears to bring health benefits, especially for more sensitive individuals. Efforts to eliminate residential radon appear to be misguided; Cuttler and Sanders[30] have recommended a limit for radon concentration in homes that is about 7 times higher than the US Environmental Protection Agency's radon action level.

The significant increase in the lifespan of short-lived dogs, chronically exposed to α-radiation from 1 inhalation of a small amount of plutonium aerosols, suggests the activation of very powerful signaling mechanisms. Studies should be carried out on mammals to understand this phenomenon. Such studies could lead to the discovery of important medical treatments for life-shortening diseases.

The results of this review suggest the need to change radiation protection policy. Obviously, maintaining exposures as low as reasonably achievable is very likely detrimental.

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RMCC SLOWPOKE-2 Facility: 30 Years of Service to The Department of National Defence

by P. SAMULEEV, P.K. CHAN[1], H.W. BONIN[1], B. BALL[1], S. JENNER[1], C. MCEWAN[1], P.C. BUNGLER[1]

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Abstract

The SLOWPOKE-2 nuclear research reactor at the Royal Military College of Canada (RMCC) went critical in 1985 and successfully served to the Department of National Defence (DND) ever since. Originally intended to be an educational tool, SLOWPOKE Facility successfully implemented many other capabilities over the years of service, such as neutron activation analysis, neutron radiography, delayed neutron analysis and nuclear forensics, production of small amounts of short-lived radioisotopes and radiation processing.

The SLOWPOKE-2 Facility capabilities and continuous enhancements are discussed.

1. Introduction

The Safe Low Power C(K)ritical Experiment (SLOWPOKE) nuclear research reactor was installed at RMCC in 1980s. In August 1985, the low-enriched uranium reactor fuel and beryllium reflectors were received and the reactor went critical in September of 1985. Installation of the reactor was intended to provide an education tool for members of the DND and an affordable neutron source for the application of neutron activation analysis (NAA) and radioisotope production. The SLOWPOKE-2 Facility supports teaching at the undergraduate and postgraduate levels, and runs laboratory courses in the programmes of Chemical Engineering, Chemistry, Engineering Physics and Physics. Engineering Design and Senior Projects were provided to students in Chemistry and Physics. As a result, over the past 30 years more than 120 postgraduate degrees in Nuclear Engineering were awarded at RMCC. Our contribution for an IAEA Compendium on the utilization of research reactors for academic education was reported in 2015 [1]. Hardware and operating systems were significantly improved. In addition to NAA, delayed neutron counting system (DNCS) [2] and neutron imaging systems [3] were developed and installed in the Facility.

2. Neutron Radiography

Neutron radiography is a non-destructive technique utilizing the neutron flow produced by the SLOWPOKE-2 reactor. This method allows for the discrimination of materials of similar density and provides a picture of the internal structure of the object.

Neutron radiography functions on the basis of transmission of neutrons through material samples. A neutron beam is directed onto an object of interest and, because neutron interactions with materials vary with composition and density of the target, an image of the internal structure of the object is produced. Neutrons have a large penetration depth into most materials, and in particular low mass materials. Neutron radiography is successfully used to study the internal structure of CF-188 flight surfaces [4], detecting abnormalities in the internal structure such as moisture ingression, structural corrosion, and physical damage.

The internal structure of a CF-18 flight surface is comprised of a honeycomb composite (Fig. 1). Under operating conditions, a CF-18 wing undergoes severe stresses. These stresses cause damage which is both difficult to detect and costly to fix if left unattended. Moreover, structural damage may result in catastrophic situations during flight. Routine neutron radiography allows the maintenance of these flight surfaces through identification of problem sites while they are still manageable thus reducing cost and increasing reliability and safety of equipment.

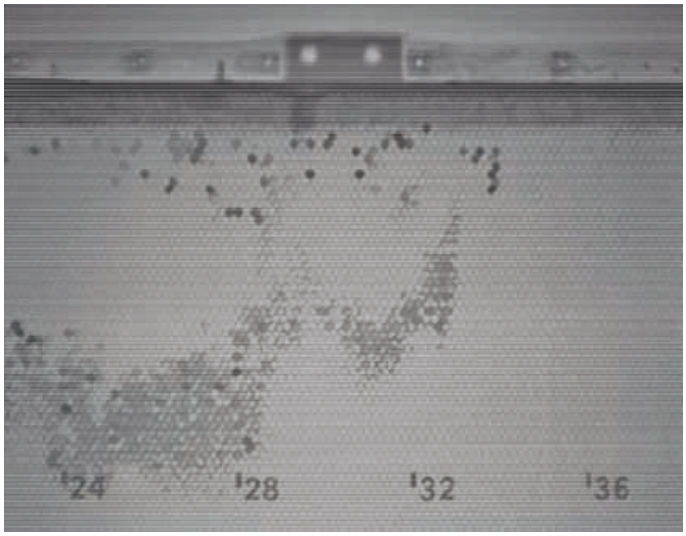

Figure 1 Water ingress in the honeycomb structure of CF-118 rudder.

3. Delayed Neutron and Gamma Counting System and Nuclear Forensics

SLOWPOKE-2 Facility actively participates in the development of the Canadian Nuclear Forensics Lab Network along with the Canadian Nuclear Safety Commission, Canadian Nuclear Laboratories, Defence Research and Development Canada, the Royal Canadian Mounted Police, Health Canada, the National Research Council, Public Safety

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Canada and the Department of Foreign Affairs, Trade and Development. Recently the Facility successfully took part in several forensic exercises, including fourth Collaborative Materials Exercise conducted by the Nuclear Forensics International Technical Working Group. Gamma and Alpha spectroscopies, Liquid Scintillation Counting, Inductively Coupled Plasma Mass Spectroscopy and other types of analyses were used. Currently SLOWPOKE-2 Facility implements the use of the Delayed Neutron and Gamma Counting System (DNGC) for the nuclear forensic analysis.

DNGC has recently been developed and built in the SLOWPOKE-2 Facility. This system detects the temporal behaviour of delayed neutrons that are released from fission products thereby giving RMCC the ability for rapid non-destructive detection of uranium and plutonium in special nuclear materials which is important for the nuclear forensics analysis. Delayed particle measurements from this system are compared to MCNP6 simulations in collaboration with the Monte Carlo Codes group at Los Alamos National Laboratory.

4. Neutron Activation Analysis

The very stable thermal neutron flux produced by SLOWPOKE-2 is ideal for an analytical technique known as neutron activation. Neutron activation analysis (NAA) is a sensitive tool that provides the ability to determine the elemental composition of materials and is one of the cornerstones of the reactor use at the RMCC. Around 1500 samples of various natures are analyzed at the SLOWPOKE-2 Facility annually.

NAA has advantages over other experimental techniques for it requires only a small amount of sample material, non-destructive, has very little sample preparation involved, and is able to perform multi-element identification efficiently while having extremely sensitive detection limits.

RMCC employs neutron activation techniques for many projects including the analysis of trace elements for quality control in plastics, analysis of various research materials for very low trace concentrations of contaminants, gamma ray spectroscopy on water, seawater, soils, biota and cement dust, cleanup by first responders during exercises, and for teaching of undergraduate and graduate students.

5. Radiation Processing

Thanks to its open pool concept, the SLOWPOKE-2 nuclear reactor allows the research staff and students to carry out radiation processing of materials. Samples could be subjected to a long-duration of gamma irradiation in a reactor pool outside the reactor container in the close vicinity of the reactor core or to a mixed field radiation in the flooded irradiation site.

Most of the research carried out at RMCC in this domain has investigated polymer based composites as potential materials for the fabrication of leak-tight containers intended at isolating the spent CANDU nuclear fuel and other radioactive waste from the biosphere for periods up to 500 years and more in a harsh environment representing the conditions of disposal of the radioactive materials deep underground in the Canadian Shield. The NSERC funded research has permitted to identify several candidate composite materials such as PolyEtherEtherKetone that compare favourably with metals and alloys both in mechanical strength and in resistance to radiation and corrosion.

6. SLOWPOKE-2 Control System Upgrade

RMCC continuously upgrading and reinvest in the facility to develop new instrumentation and nuclear capabilities. In 2001 original analog control system was replaced by the digital SLOWPOKE-2 Integrated Reactor Control and Instrumentation System (SIRCIS) designed and built at the RMCC. In 2012 the system was updated to Version 2. SIRCIS V2 system collects signals from the neutron flux detector and regulates the control rod position based on the desired operating conditions. It also provides the visual information about the temperatures and water levels in the pool and the reactor core.

In keeping with professional and workmanlike approach the work on the Electrical Certification of the SIRCIS V2 system (ESAFE from the Electrical Safety Authority) is ongoing at the SLOWPOKE-2 Facility to bring all the electrical components and documentation of the system to the modem standards.

It is expected that ESAFE certification of the SIRCIS V2 system will be finalized in 2017.

7. Conclusions

The SLOWPOKE-2 nuclear research reactor is a powerful and important scientific resource for the DND. Nuclear capabilities provided by the reactor such as DNGC and neutron imaging are used to measure and evaluate a wide range of issues significant to the DND. Due to its continued relevance, the DND is committed to reinvesting and upgrading the facility and instrumentation.

After 30 years of successful operation, DND is planning to refuel the SLOWPOKE-2 Reactor at RMCC by 2018.

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Update on an Alzheimer patient treated with CT scans

by JERRY M. CUTTLER[1], EUGENE R. MOORE[2], VICTOR D. HOSFELD[3] and DAVID L NADOLSKI[4]

[The following letter, submitted to the Bulletin by the author, has been published in Dose Response: An International Journal, January-March 2017:1-6.]

Dear Editor

This letter updates the April 2016 case report[1] about an 81-year-old patient who was in the final stages of advanced Alzheimer disease (AD) in hospice care. A neuropsychologist examined her on May 21, 2015 and concluded that she was "completely nonresponsive." Following treatment by 4 computed tomography (CT) scans of the brain from July to August 2015, the patient made a remarkable recovery. A fifth scan on October 1 caused a setback, from which she gradually recovered. On November 20, she was judged to be no longer eligible for hospice care because her condition was sufficiently improved. Since then, she has participated in a stimulating, dementia day care program. Photos on December 4, 2015, Figures 1 and 2, demonstrate restoration of appetite and responsiveness.

Recognizing that the efficacy of the CT scan treatments would likely be transitory, the patient's spouse requested ongoing booster scans every 4 to 5 months. These started on February 24, 2016, about 21 weeks after the October 1 treatment.

Dr. William D. MacInnes re-examined the patient on April 15, 2016. His progress note states:

> Unlike our last visit, Mrs. XXX was able to give simple verbal responses to direct, simple questions. Not all of her responses were related to the direct questions, but she seemed to be reacting appropriately to the prosody and nonverbal cues of those around her. This represents some improvement from October 12, 2015 when I last saw her. ... Mr. XXX reported that his wife is no longer receiving services through hospice at this time because of her lack of decline. He indicated that she was able to get out of the car by herself with some standby assist. However, she has not resumed walking independently. Mr. XXX reported that his wife occasionally feeds herself, but she still requires cueing.

The dates and doses[2] of all x-ray scans are listed in Table 1. (The nominal dose of a CT scan of the brain is about 40 mGy.) When a slight decline in the patient's condition was observed, the interval between booster treatments was shortened from 4 or 5 months to about 6 weeks.

Figure 1. Restoration of appetite of patient with Alzheimer disease (AD).

On discovering the efficacy of CT scans for Alzheimer disease, the patient's spouse requested a scan to alleviate symptoms of his Parkinson disease (PD), which is also a neurodegenerative disease. While in bed on the night after the first scan, he observed a complete

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Table 1. Date and x-ray dose ($CTDI_{vol}$) of the treatments of the patient with AD

Date	Interval (days)	Dose (mGy)
July 23, 2015		82**
August 06, 2015	14	39
August 20, 2015	14	47
October 01, 2015	42	39
February 24, 2016	146	40
June 22, 2016	119	40
October 27, 2016	125	40
December 13, 2016	47	40
January 24, 2017	41	80**

**Two CT scans

Table 2. Date and x-ray dose ($CTDI_{vol}$) of the treatments of the patient with PD

Date	Interval (days)	Dose (mGy)
October 06, 2015		40
June 16, 2016	253	40
July 13, 2016	28	40
September 29, 2016	51	40
November 21, 2016	80	40
December 21, 2016	30	40

absence of tremor while sleeping and waking at about 4 AM. Soon afterward, he decreased his medication† from 6 to 2 or 3 pills per day. On June 13, 2016, he received an in-depth neuropsychological examination. The subsequent CT scans that he received are listed in Table 2. Based on this experience, he prefers the 4-week interval. Further neuropsychological examinations will be carried out to document the changes in his condition.

Based on these 2 cases, it appears likely that treatment by CT scans of the brain may relieve symptoms of both AD and PD. The authors recommend that clinical studies be carried out to develop optimal treatments. The mechanism is likely x-ray stimulation of the patient's adaptive protection systems against neurodegenerative diseases.

† Carbidopa/levodopa, 25/100 mg

Figure 2. Response of patient with Alzheimer disease (AD) to request to look at the camera.

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Women of the Montreal Laboratory – III

by GILLES SABOURIN

Here is a follow-up to the articles of December 2015 and December 2016 on women who worked in the Montreal Laboratory during WWII.

Women in non-technical positions:

Annette Ruth Wolff (1911-2012)

Annette Wolff was born in April 1911 in Montreal. Her mother was Irene Joseph (1885-1940) and her father was Martin Wolff (1881-1948). The Joseph family was one of the first Jewish families to settle in Quebec. Annette's great-grand-father, Abraham Joseph (1815-1886), was a successful businessman, assuming leadership roles in the Quebec Board of Trade and in the Banque Nationale.

In the first part of the 20th century, a lot of Jewish people fleeing pogroms and general discrimination in Europe came to the United States and Canada. The Jewish community in Montreal, the second in importance after New York, grew up to approximately 60 000 souls at the beginning of WWII. The Wolff family (Irene and Martin Wolff had six daughters), although observant Jews, mixed with and were accepted by the larger community.

Annette Wolff graduated as a dental hygienist from the Forsyth Dental Infirmary in Boston in 1931. She was employed in various capacities during her adult life. At the beginning of WWII, she was an international switchboard operator at the London Telephone Exchange. In 1940, she came back to Canada to take care of her mother and one of her sisters who were very ill, and would pass away within a year. Because of the dangers of crossing the Atlantic, she was not allowed to go back to London to be reinstalled in her position.

She then worked in the Montreal area in the munitions industry as an administrative clerk until 1944 when she was hired by the Montreal Laboratory. After the war, she worked at the Harwell Research Establishment, south of Oxford, UK. She was a prolific writer of letters, essays, poems and plays. She was a chronicler of her time and an avid collector of all things naval. She is a founding member of the Montreal branch of the World Ship Society.

In 1999, Eiran Harris recorded more than 10 hours of interview with Annette Wolff, aged 88, on her life history. The audio tapes on which the interviews are recorded are kept at the Alex Dworkin Canadian Jewish Archives in Montreal. She described in some detail her work for the Montreal Laboratory between 1944 and 1946.

She was hired by Tube Alloys as an administrative clerk for Mr. R.C. Nickle who was working in the administration of the Montreal Lab. Rumor had it that Mr. Nickle, having worked overseas for the army at the beginning of the war, had been repatriated because of 'elbow lifting' (alcoholism). Annette was soon to find out that the rumors were right, doing most of the work that her boss was supposed to do, while he was sleeping in his office. Her duties were to relieve the scientists from administrative burdens, to keep meeting schedules, etc.

Annette Wolff in 1998 (provided by the Alex Dworkin Canadian Jewish Archives)

From her interview, we get the general sense that Annette considered the Tube Alloys scientists as a group of 'brains' that needed to be cared of because they were not skilled at common day-to-day tasks. She kept good memories of several of the scientific staff, including John Cockroft (director of the Laboratory), Leo Yaffe (in the Chemistry Division), Edward Guggenheim, Herbert Freundlich, Lew Kowarski, Jules Guéron, etc.

Later in life, Annette Wolff spent considerable time in recording the history of her family and of the synagogue that she attended, the Spanish and Portuguese Synagogue of Montreal. She died in 2012, at the incredible age of 101.

Daphne Sebag-Montefiore (1915-)

Daphne Celine Sebag-Montefiore was born in June 1915 in Montreal. Her father was William Sebag-Montefiore, a British businessman who shared his time between England and Canada. Her mother was Sybil Matilda Joseph. Through her mother's side, she was a distant relative of Annette Ruth Wolff. Her mother died when she was an infant. He father remar-

Daphne Montefiore on a Red Cross motorcycle during WWII

ried with Margaret Maude Joseph, and older sister of his former wife. They had together two children (Robert and Nancy), Daphne's stepbrother and stepsister.

The Sebag-Montefiores moved several times back and forth between England and Canada during the 1920s and 1930s. On September 2nd 1939, one day after the Wehrmacht invaded Poland thus starting World War II, Daphne Sebag-Montefiore embarked on the steamship Athenia in Liverpool for Montreal via Belfast, Ireland. Aboard the SS Athenia were 1103 passengers, including about 500 Jewish refugees, 469 Canadians, 311 Americans, 72 British and more than 300 crew members. On the evening of September 3rd, while the ship was 370 km northwest of Ireland in the North Atlantic, it was torpedoed by a German U-boat. The SS Athenia sent a distress signal that was answered by several ships. The Athenia sank in the ocean 14 hours after the attack. One hundred and seventeen people were killed. Four ships (a US cargo ship, a Norwegian tanker, a Swedish yacht and a British destroyer) saved the majority of passengers, including Daphne Sebag-Montefiore.

Among the passengers was also John Lawrence (brother of Ernest Lawrence, the inventor of the cyclotron), a professor of physics at Berkeley in California, who would pioneer nuclear medicine by using radioactive phosphorus for treating leukemia.

After a safe arrival in Montreal, Daphne decided to do her part in the war effort and joined the Canadian Red Cross Society in their Transport Division. Composed almost entirely of women, the Transport Division served in a variety of purposes, mainly delivering goods and food for people engaged in the war effort. The Montreal Laboratory delivered authorization to six women of the Canadian Red Cross Society Transport Division to enter the premises. Daphne Sebag-Montefiore was among those women. During the war, she was promoted to the position of commandant of the Montreal detachment of the transport section.

Daphne Montefiore (as she liked to be called) joined the Girl Guides of Canada in 1924, when she was 9 years old, and remained involved all her life, holding prominent roles as a guider and a trainer. In 2014, a special event was organized where Daphne received the first-ever 90-year service pin!! She was also for a long time volunteer for Tel-Aide, a crisis phone line, often working the overnight shift.

She was not a person afraid by challenges in the endeavors that she decided to perform. In 1947, with two friends from Montreal (Kay Sauer and Rosalie Briggs), she crossed Canada in a convertible car, from Montreal to Vancouver, despite bad roads, a flood near Winnipeg, and highway official's warnings. Taking camping equipment with them in a trailer, they pitched their tent each night and didn't spend a cent on accommodation all the way across. After Vancouver, they headed south to San Francisco, crossed the southern United States and came back home along the East Coast.

Daphne Montefiore is still living in Montreal, aged 101 years old.

Other women related to the Tube Alloys Project:

Brenda Langford Milner (1918-)

Brenda Langford was born on July 1918 in Manchester, England. Her father, Samuel Langford, was a music critic, and her mother, Leslie Doig, was a singer. Although both her parents were musically talented, she had very little interest in music. When she was 6 months old, her mother and her contracted the influenza, the same strain that killed between 20 and 40 million people after WWI. Luckily, they both survived.

In 1936 she started a degree in mathematics at Newham College in Cambridge, having received a scholarship. After realizing that she was not 'perceptive' enough for mathematics, she changed her field of study to psychology.

She graduated from Cambridge in 1939 with a degree in experimental psychology and gained a scholarship to continue to postgraduate studies. Because of the war, the laboratory where she was studying, the Cambridge Psychological Laboratory, was diverted to applied research in the selection of aircrew. Langford was on a team that developed perceptual tasks for selecting aircrews, trying to distinguish fighter pilots from bomber pilots using aptitude tests.

From 1941 to 1944, she worked for the Telecommunications Research Establishment, which is best known for its research on radar. It was initially located in Swanage, on the English Channel and moved to Malvern in central England, because of fear of German raids. She investigated the different

methods of display and control to be used by radar operators. It is while working in Malvern that she met Peter Milner, an electrical engineer. In his own words: "When Brenda Langford came to help us compare different settings of the machine/operator interface of my simulator, she rapidly became a dominant influence in my life. I was in some awe of her; she had an excellent Cambridge degree and was very competent in her work. We had a good friendly relationship, but I did not feel very competitive, especially after my recent bad experience. The establishment was overrun by brilliant Cambridge physicists so I did not think she would be interested in an engineer from Leeds."

In the autumn of 1944, Peter Milner was asked if he had any objection to going abroad for a year or two, to work on the secret Tube Alloys project. He was eager to go, but for him, there was a serious flaw in the arrangements that were proposed: "spouses were allowed to accompany the appointees, but girlfriends received no mention."

So he proposed to Brenda who to his delight and surprise accepted. A few days later, they were married and en-route to Montreal via New York aboard the Queen Elizabeth. In Montreal, Peter was charged with different engineering problems related to the cooling of the large reactor that was to be built in Chalk River (the NRX). His work involved often travelling to the site. In 1946 his position was moved to Chalk River.

After her arrival in Montreal, Brenda Milner found a job teaching comparative psychology (in French) at the University of Montreal. She had always loved languages, and when she was in Malvern, she had found someone to teach her conversational French. She stayed as a professor at Montreal University for 7 years. When her husband moved to Chalk River, she visited the place, but did not like it, because of its isolation and lack of opportunity for her, and came back in Montreal. She enrolled at McGill University and graduated with an M.A. in experimental psychology in 1949 and a Ph.D. in 1952.

In 1946, Peter Milner decided to make a life-changing decision, resign from his position at Chalk River and enrolled as a graduate student in the Psychology department at McGill, and working in parallel part-time for the physics department on the construction of the new cyclotron. He won his M.A. in 1950 and his Ph.D. in 1954. He was accepted as a Professor in the Psychology department of McGill in 1955 and in 2016, is still listed as an emeritus.

In 1954, Brenda Milner published a paper entitled "Intellectual Function of the Temporal Lobes" in which she shows that temporal lobe damage (or removal by surgery for some extreme cases) can cause intellectual and emotional changes in humans. She was a pioneer in the field of neuropsychology and the study of memory and other cognitive functions.

She is best known for having described the deficits of the most famous patient in cognitive neuroscience, Henry Molaison, known for a long time by his initials (H.M.) until his death in 2008 at the age of 82. Henry Molaison had undergone a bilateral temporal lobectomy (removal of the front part of the brain by surgery) in an attempt to cure his severe epilepsy. As a result of this surgery, Molaison lost his short term memory.

The case of Molaison was first reported by a paper by Brenda Milner in 1957 (Loss of recent memory after bilateral hippocampal lesions) in the Journal of Neurology, Neurosurgery and Psychiatry. She showed that although he could not remember anything that had happened for more than 15 minutes (including meeting her the previous day), he could still learn to perform new tasks. This led Milner to assume that there are different types of memory systems (the episodic system and the procedural system).

Brenda Milner holds honorary degrees from more than 20 universities and continues to work in her nineties. She is the Dorothy J. Killam Professor at the Montreal Neurological Institute and a Professor in the department of Neurology and Neurosurgery at McGill. She is currently studying bilingualism and the difference in neural pathways used to acquire new and native languages, with her collaborator Denise Klein. In November 2015, aged 97 years old, she travelled to Alberta to accept an honorary degree from the University of Calgary. She addressed the Class of 2015 with a lively speech telling the students not to be afraid of changing their career paths: "Occasionally one finds that one has made the wrong choice. I did in my career. I started in mathematics and I changed to neuropsychology and neuroscience. If you find real temptation, real excitement somewhere else, don't be afraid to change. La vie est longue".

Brenda and Peter Milner divorced in the 1970s. They remained good friends and speak to each other every day. If it had not been for the Tube Alloys Project, Brenda Milner might not have found the opportunities that made her, as some people call her, the founder of neuropsychology.

Brenda and Peter Milner are both alive and well, living in Montreal, aged 98 and 97.

Other women who worked in the Montreal Laboratory

Several other women worked in the Montreal Laboratory. Among them are:

- Yvette Diamond: trained in physics, she met the New Zealander Charles Watson-Munro in the Montreal Laboratory. They married in 1947 in

London. They lived in New Zealand and Australia. Yvette died in 1989.

- Patricia Agnes Gorie: (no 24 in the group photo) she worked in the chemistry department. She is co-author of 2 reports with Alfred Maddock ("Homogeneous media", MC-43; "Comments and tests on methods of determination of water in anhydrous uranyl sulphate and other salts", CI-46). After the war she married David W.W. McLean. They had a son, David Walker McLean.
- Eileen Lyttle: she worked as an assistant in the chemistry department with Bertrand Goldschmidt. She married William Frederick Fenning who later worked in Chalk River and in Harwell.
- Gerda Madgwick: (no 25 in the group photo) she worked as a scientist in the Chemistry Division in Montreal. She married James Ralph Leicester, an engineer working in the Montreal Laboratory. She worked at Harwell and published papers on the utilization of radioactive isotopes. Her second husband is Jack Sutton who also worked in the Montreal Laboratory. In 1955 she resigned from her position at Harwell, moved to France and started a new life as an artist painter. She died in Paris in 2005.
- Sara Paul: born in Kupiskis Lithuania in the 1920s, she arrived in Montreal with her family at a young age. She worked in the Montreal Laboratory as a technician assisting Henry Seligman. She met Ernest Courant in the Lab and eventually married him. They moved to Long Island where Ernest worked at the Brookhaven National Laboratory. They are both still alive and sharp.
- Margaret Wilson: she worked in the instrument division of the physics department. She is the co-author of one report with Norman Veall ("On the construction of small boron chambers and Geiger-Mueller counters used in Montreal Laboratory May 1943 - May 1944", MP-60). She married Lloyd George Elliott a co-worker in the Montreal Laboratory. They had three children born in Deep River. In her 40s she returned to university and got B.A. and M.A degrees. For 12 years she taught English as a second language in South Korea. She died in February 2016, aged 91 years old.

Conclusion

I don't know which conclusion to draw from all this, except that all these women lived very long lives. Perhaps low intensity radiation is not so bad after all!

Many people helped me in my research for this paper. I want to thank specifically Kate Sebag-Montefiore, niece of Daphne Montefiore, Janice Rosen from the Alex Dworkin Canadian Jewish Archives, and my wife, Claude Lefrançois.

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Douglas Point: Canada'a First Full Scale Nuclear Generating Station

by RIC FLUKE

Fifty years ago on 7 January 1967 the newly constructed Douglas Point Nuclear Generating Station supplied its first electricity to the Ontario grid. Criticality had been achieved in 1966 and the station continued to supply electricity until its permanent closure on 5 May 1984. It followed on the heels of the Nuclear Power Demonstration (NPD) reactor, scaled up in power from 22 MWe to 220 MWe (a tenfold increase in output to match typical power plants during that era), but there was a slight "glitch" in the scale-up. To resolve the glitch, as will be explained below, the design of NPD itself was changed to match the revised Douglas Point prototype that would be the basis of all future CANDU™ reactors.

The world of CANDU, of course, has moved on. But despite a number of technical problems usually encountered in a "first-of-a-kind" technology, the 17 years of operation of Douglas Point was invaluable in providing world class expertise in research, design, manufacturing and operation as well as reactor exports abroad. Here is how it began.

With the distractions of World War II now behind us Canada, with its well established and world renown nuclear industry could now focus on peaceful uses of atomic energy. Uranium, once a waste by-product of the lucrative Radium industry, was now looked upon as an enormous source of energy production. At the Chalk River Laboratories research reactors such as ZEEP, NRX and NRU had proven the concept of heavy water reactors with valuable contributions to science and medicine. But Ontario had another need.

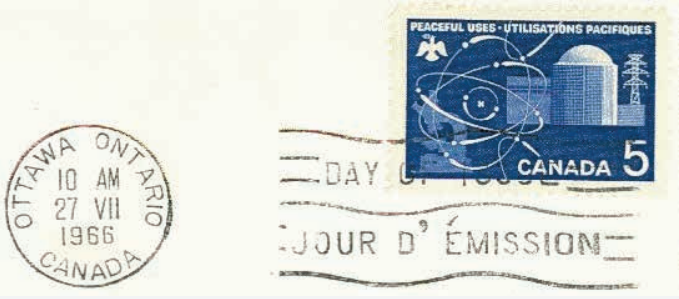
In the 1950s the post-war demand for electricity was skyrocketing and in Ontario sources of major traditional hydro electric generation were already used up. Ontario was importing (at great expense) oil and coal to meet Ontario's growing electricity demand and the then Hydro Electric Power Commission of Ontario (HEPCO) was receptive to a new concept proposed by Atomic Energy of Canada Limited (AECL) - the use of indigenous uranium[1] to produce electricity. The governments of Canada, Ontario and private corporations worked in partnership to design and build a nuclear generating station, as a demonstration of concept, called the Nuclear Power Demonstration (NPD) on the Ottawa River near Rolphton.

The early design of NPD (which would later be known as NPD-I) was a scale-up of the successful heavy water reactor at Chalk River, the Nuclear Research Universal (NRU). However, for reasons of efficiency in turbine operation to drive a generator, the coolant would need to be pressurized to 100 times that of NRU, producing water temperatures of 300°C (compared to 100°C at NRU). This would require the heavy water core to be enclosed in a strong pressure vessel. The technology to forge such a vessel did not exist in Canada, and a special forging was manufactured in Scotland for NPD-I. But already, HEPCO was thinking ahead and it was realized that the technology to forge even bigger pressure vessels was not then available anywhere. At the same time Chalk River was researching the properties of a new exotic metal, zirconium. This was research that was funded by the US to determine the feasibility of zirconium pressure tubes for its Hanford reactor. Zirconium is strong, can be formed into tubes that could withstand high pressure, and it is transparent to neutrons. NPD-I would generate 22 MWe, but a full scale prototype (at 220 MWe) was needed by HEPCO. The idea of a pressure vessel for a prototype of that scale was abandoned.

NPD-I was already under construction and the pressure vessel from Scotland would soon be delivered, but that too was abandoned. The design of NPD-II would

1 Although Ontario has large supplies of Uranium, today Saskatchewan is the major supplier of CANDU fuel.

become a pressure-tube heavy water reactor. It would also have on-line refuelling of its horizontal fuel channels, and to accommodate the length of the fuelling machines (one on each end) the hard rock granite that forms the Canadian Shield, which had already been excavated for NPD-I, had to be re-carved to make room for NPD-II. Over some time, the "NPD-II" designation was dropped and the reactor was known simply as NPD.



Even before NPD went critical (it operated from 1962 to 1987) AECL opened a new design office in 1958, the Nuclear Power Plant Division located in Toronto (later moved to Sheridan Park in Mississauga), with staff from AECL, HEPCO, CGE and other partners. Several sites along the shore of Lake Huron, from Goderich to North of Manitoulin Island were considered, but the location that was selected had a solid limestone bedrock, making it ideal for the station. The station was named after its location, Douglas Point, between Port Elgin and Kincardine. HEPCO purchased 2300 acres at the predominantly farming lands for about $60 an acre. Construction began in 1961. Ontario would not wait until NPD had proven the concept, so confident (and brave) were the engineers of AECL and HEPCO.

Problems arose and had to be resolved during construction, a big one being the inadequate quality of valves and fittings to contain (very expensive) heavy water at high pressure. Even after commissioning in 1966, before connecting to the grid, the station was shut down for repairs. CANDU reactors are very compact and there is hardly any "knuckle room" for workers to set their wrenches; thus a lot of work had to be done with special tools, and large teams of workers were needed to minimize individual radiation dose.

Despite problems with "first-of-a-kind" technology, the engineers found solutions. First power to the grid occurred on 7 January 1967, 50 years ago! Remarkably, design of Pickering had already commenced in June 1963, and HEPCO announced its commitment to build Pickering in the Spring of 1964, before the prototype had produced any power [1]. This was another very bold decision of the engineers of the time.

Douglas Point operated until 5 May 1984, and by then was achieving a reasonable capacity factor of more than 80%. Unfortunately, the pressure tubes needed to be replaced, a fact that is now part of the design of CANDUs. This had already been done in Pickering

Units 1 and 2, and would be done in later CANDU refurbishment projects at Point Lepreau and Bruce A Units 1 and 2, and is planned for upcoming CANDU refurbishment projects at Bruce and Darlington stations. But it would not be done for Douglas Point.

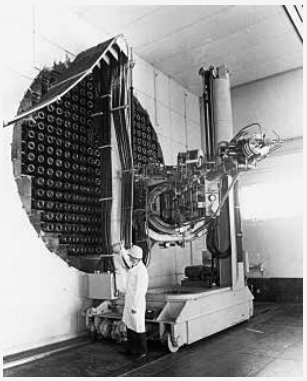
Ontario Hydro (renamed form HEPCO in 1974) was encouraged by the successful Pickering reactors (540 MWe) since 1971, and was already operating the 750 MWe Bruce Reactors and constructing the 880 MWe Darlington Reactors, four times more powerful than Douglas Point. The small output of Douglas Point and the high cost of refurbishment were factors leading Ontario Hydro's decision not to continue operation of Douglas Point. The prototype had served its purpose and it was time to move on.

Douglas Point was and continues to be owned by AECL. It was operated by Ontario Hydro, but Ontario Hydro declined to purchase the station from AECL; the station was a small dwarf on the massive Bruce Nuclear Power Development site, still owned by Ontario Power Generation who is leasing the Bruce reactors to privately held Bruce Power. Bruce Power has invested heavily in the refurbishing and upgrading site, bringing all eight units into operation (something not possible in earlier years due to transmission line bottlenecks). As a result of Bruce Power and its private investors the Government of Ontario was able to achieve its vision to completely phase out coal for electricity generation, eliminating a very significant source of GHG emissions.

Although the familiar dome of the Douglas Point station can still be seen, and much original equipment remains, Douglas Point was a huge success in many ways. More than just a "learning curve" for a "first-of-a-kind" endeavor, it established AECL and Ontario Hydro, with their multitude of private suppliers, as world leaders in nuclear technology and was instrumental in overseas sales of CANDU reactors and nuclear services. As stated in Jeremy Whitlock's essay

to the Ontario Heritage Trust, 2005 [2]:

"Canada's CANDU reactor remains a competitive and leading design in the global market, with major features that are directly traceable to the engineering decisions at Douglas Point ... As with the NPD project at Rolphton, Douglas Point demonstrated the symbiotic benefits that can come of federal/provincial/private cooperation in research and development. The partnership forged in those pioneering years between AECL and Ontario Hydro continued and prospered – and served as a model for other utilities in Québec and New Brunswick that later installed CANDU reactors. The participation of private manufacturing and engineering firms has evolved into a well-established nuclear industry to which most CANDU construction and design contracts are now channelled."



Douglas Point NGS remains a distinctive landmark on the Bruce site.

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Photos courtesy of Chalk River Nuclear Laboratories. (CNL)

News from Branches

BRANCH AFFAIRS CHAIR (BAC)

by Ron Thomas

During the reporting period the UK Nuclear Institute accepted the CNS's invitation to send a visiting speaker to Canada under the Society's new, "Shared Cost Speaker Exchange Program".

The NI representative will give presentations to CNS members at various Branch locations in New Brunswick and Ontario during the week of October 30 – November 03, this year.

In 2018, the NI will host a reciprocal speaking visit to the UK by a CNS expert.

Together with the President/ Peter Ozemoyah, the Past President/Paul Thompson, the Secretary/Colin Hunt, and the Ottawa Branch Chair/Ken Kirkhope, the BAC participated in a Relationship Meeting with the top echelon of the Canadian Nuclear Safety Commission (CNSC).

The view on the CNS side was that the discussions were of a positive and encouraging nature, the senior CNSC staff acknowledging the shared interests of the two organizations and expressing support for the 'Society's outreach and other work.

Contact between representatives of the CNS and the CNSC following the meeting are continuing.

Acting quickly to respond to one of the outcomes of the last December All-Chairs meeting, Durham Region Branch, in concert with UOIT Branch, has organized and obtained material support for, a Nuclear Job Fair to be held at UOIT in October, this year during the 2017 Nuclear Science Week in North America. This will be a major CNS-driven event by the Branch network.

Bruce Branch has been instrumental in opening up a major advertising opportunity for the 'Society at Bruce Power, something that, among other things, might facilitate an increase in CNS membership.

CNS President, Peter Ozemoyah visited and was well-received at the following Branches during the period: GHS, Ottawa, Chalk River, and Toronto. At each location the President gave a presentation on the origin of the Society and its programs, and the ways in which the 'Society serves the Canadian nuclear community. Dr. Ozemoyah intends visiting each of the rest of the Branches before the end of his tenure in June this year, 2017.

Branch Activity Reports

Golden Horseshoe Branch/Jason Sharpe

On February 17th the CNS president Peter Ozemoyah met with the CNS GHS branch executives, then presented a seminar on CNS operations, goals, and structure, then joined us for a lunch afterwards with CNS members, students, and faculty.

On February 28th, Lei Zhu, a McMaster researcher, presented his work on the High Flux Engineering Test Reactor at the Nuclear Power Institute of China.

On March 1st, Mark Jensen, the director of DGR Geoscience and Research at NWMO, presented the research and development of the proposed DGR.

**Planning has begun to hold a "A Night Out for Nuclear!", presented by Jacques Plourde, at McMaster's Phoenix Bar and Grill on April 3rd. All are welcome to join!

Durham Region Branch/Jacques Plourde and Nick Preston, Co-Chairs

Activities are underway to launch the new CNS Branch that will serve Durham Region, and provide better CNS-OPG alignment.

Current Branch Executive:

- o Nick Preston (Co-Chair and Secretary)
- o Jacques Plourde (Co-Chair and Treasurer)
- o Polad Zahedi (Utility Rep and Branch Webmaster)
- o Dan Meraw
- o Dan Meneley
- o Alim Baytekin (identified as future Co-Chair, to replace Jacques Plourde)

The executive has met 5 times to expedite preparations for a strong revival of what used to be the Darlington and Pickering Branches.

Summary of the discussions are as follows:

- The former Pickering Branch bank account has been closed.

- A series of four lunch and learns to advertise the launch of the Branch are planned to start on the first week of April. Locations and executive sponsors have been secured and speakers are being selected.
- Council approval has been given for a Nuclear Job Fair is planned at UOIT for October 21st. Support has been secured from OCNI, OPG Refurb, Ian Martin Group and the Unions representing Nuclear Workers.
- Outreach to Secondary Schools: A Pilot CNS-OCNI project to be discussed at the next OCNI Education & Skills Development Committee, on Mar 9.
- In April, or May at the latest, a Branch Launching event is planned. This would be a social event (dinner) with a keynote speaker.

New Brunswick Branch/Derek Mullin (report submitted by Paul Thompson)

The Branch had planned for a talk on February 13th by Mr. Jacques Plourde on "Nuclear Insurance – A Risk Control Engineer's Perspective" and on the CNS Strategic Plan, unfortunately however this had to be postponed due to the a winter storm that affected both Eastern Canada and the Maritimes. The lecture will be rescheduled for a later date. On the evening of February 28th, Benoit Poulet, Director of Point Lepreau and G-2 Regulatory Program Division of the CNSC, gave a talk in Saint John on the IAEA International Report System, and the application of the system with specific reference to the Kakrapar Pressure Tube Failure Event(s) in India. The talk was also repeated the next day at a lunch and learn session at the Point Lepreau Generating Station. Both sessions were well attended, attracting a total of about 54 people. This concept of a double header meeting is intended to make it easier for Non-PLGS employees such as those who are either retired, in University, or other interested Engineering professions to attend, and to more easily attract station employees. The lunch and learn at the station idea was suggested at the CNS/NB Power relationship meeting by Brett Plummer, VP Nuclear and Chief Nuclear Officer, who is quite supportive of the CNS. Other exciting events are being planned for the near future.

Western Region Branch/Matthew Dalzell

General

The Branch was largely quiet over the winter period.

Branch Activities

The Branch is still working to develop its Chapter model of local groups, with efforts started to establish a chapter in Saskatoon. The Branch Executive has conducted a videoconferencing trial using Zoom. The application was used to host the Branch's first 'face to face' executive meeting and is being considered as a platform to have guest speakers present webinars to the Branch (as well as whoever in the CNS would like to participate).

Outreach Activities

- Matthew Dalzell gave a presentation on science communications and risk perception to University of Saskatchewan students studying to be high school science teachers in January, including a discussion of the Fukushima accident and its aftermath, and radiation. He also promoted the CNS as part of presentation on nuclear as a clean energy source to the University of Saskatchewan Innovation Energy Team, a group of students interested in sustainable energy technology.
- Education coordinate Aaron Hinman will be presenting at the upcoming Earth Science for Society Exhibition in March.
- Members of the Branch Executive, led by Duane Pendergast, are also discussing potential outreach opportunities related to Alberta's shift to a capacity energy market

Chalk River Branch/Andrew Morreale

CNS-CRB CNS President's Dinner, "Fully-Integrated Mo-99 Production from NRU and CANDU" – Dr. Peter Ozemoyah (Feb. 22, 2017):

On Wednesday February 22nd, the Chalk River Branch of the CNS hosted its annual CNS President's Dinner at the Bear's Den in Deep River. There was a well-rounded crowd of 32 attendees (both CNS members and non-members). The event included a buffet dinner and discussion on the strategic plan and vision of the CNS and what it can do for its members and the industry as a whole.

Upcoming events and talks to look out for:

- The CNS Chalk River Branch will have talks in April and May (exact dates TBD) including:
  - o "Small Modular Reactor – Development, Deployment and Regulation" by a representative from CNSC.

CNS-CRB President's Dinner, Bear's Den, Deep River, February 22, 2017. CNS-CRB Exec Members pose with CNS President, Peter Ozemoyah.

Left = CNS calls you to be involved (will you answer?)
Right = Peter converses with CRB member John Hilborn.

- o "The Path Forward for R&D at CNL" Dr. Kathryn McCarthy – CNL Vice President of Research and Development.

• Upcoming events include:

- o Renfrew County Science Fair on April 8th in Petawawa (for information or if you are interested in representing CNS as a judge contact Aidan Leach, aidan.leach@cnl.ca).
- o The Renfrew County Science Olympics will be testing young minds in late May.

Ottawa Branch/Ken Kirkhope

On January 30, the Ottawa Branch hosted a presentation by Marcel De Vos, Kevin Lee and Christian Carrier of the New Major Facilities Licensing Division at the Canadian Nuclear Safety Commission. They gave a very interesting and well received presentation entitled "Update on Small Modular Reactors – Development, Deployment and Regulation" which provided an overview of the CNSC SMR discussion paper, the Vendor Pre-Project Design Review projects at the CNSC, some key international SMR activities, and paths forward and future follow-ups to the Commission. The meeting hosted was well attended and a very lively question & answer session followed.

On February 21, the Ottawa branch hosted a presentation by Dr. Peter Ozemoyah, current President of the CNS. Dr. Ozemoyah described the origin of the Society and the many program activities currently underway, and how its programs serve the public, the school systems, university students, industry, and all sectors of the nuclear community across Canada. He then held an open conversation where the participants shared their views with the President, which resulted in an interesting discussion period.

The branch executive is lining up other events for the coming months. Information on upcoming and past events can be found at the Ottawa branch web page (www.cns-snc.ca/CNS/ottawa/) as well as our Facebook and Twitter accounts.

Manitoba Branch/Jason Martino

Manitoba Branch received approval from the Whiteshell Site Head for a lunch visit by CNS President, Peter Ozemoyah. No other activity.

UOIT Branch/ Eleodor Nichita

A presentation by Tim Christie, Director of the Electricity Policy, Economics and System Planning Branch of the Ontario Ministry of Energy took place on January 31, 12.30 – 14.00h at UOIT and drew approximately 70 participants.

A talk on electric vehicles is scheduled for March 14.

Bruce Branch/John Krane

As a result of a meeting with Bruce Power CEO, the CNS has been given permission to advertise at no cost in the Bruce Power site magazine "the Point". As a result the CNS Bruce Branch Chair has submitted an advertisement notice for the 2017 CNS Annual Conference in Niagara Falls.

CNS Bruce Branch Chair and other members have received an invitation to be part of the 2017 Bluewater Regional Science and Technology Fair as a judge. The intermediate/senior fair will be held on Wednesday Apr 5, 2017 and the Junior fair on Wednesday April 12, 2017. Both fairs will be held at the Harry Lumley Bayshore Community Centre in Owen Sound, ON and Bruce Branch members will be participating and donating 2 x $50 prizes.

Bruce Branch will be contacting the CNS President to arrange a dinner meeting presentation in the spring.

Sheridan Park Branch/Rajendra Jain

The Sheridan Park Branch activity report is as follows:

A branch executive meeting was held on Feb 21 The CNS president visit and a presentation on "The Global Nuclear Market and Importance of External Relations", will be organized on April 06, 2017.

GENERAL news

(Compiled by Colin Hunt from open sources)

OPG to Produce Fuel for Space Program

Ontario Power Generation (OPG) and its venture arm, Canadian Nuclear Partners, are participating in a project to produce isotopes in support of deep space exploration. Under the agreement, OPG would help create isotopes at the Darlington nuclear station east of Toronto that will help power space probes.

"This is a very exciting project," said Jeff Lyash, OPG President and CEO. "No pursuit pushes the boundaries of our scientific and technical limits like space travel. We are proud to have Ontario play a part, however small, in this most noble of human endeavours."

Lyash noted that OPG employs a similar isotope process in its Pickering units to create Cobalt 60 for use in the sterilization of surgical and medical supplies.

The targets will be prepared at Pacific Northwest National Laboratories and then shipped to Darlington for irradiation in the reactor core. The program is expected to be up and running by 2020.

U-Battery Begins Canadian Pre-licencing Process

The U-Battery consortium, led by Urenco, has registered its micro-modular reactor technology for pre-licensing vendor design review with the Canadian Nuclear Safety Commission (CNSC).

U-Battery is a 'micro' nuclear reactor which will be able to produce local power and heat for a range of energy needs, mainly targeting the markets for industrial power units and off-grid locations. Powered by Triso fuel, each helium gas-cooled unit produces 10 MWt, can deliver up to 4MWe as electricity and can provide 750 degrees Celsius of process heat. Triso fuel comprises spherical particles of uranium fuel with a triple carbon-coating which effectively gives each tiny particle its own primary containment system.

The concept design of U-Battery was developed by the Universities of Manchester, the Dalton Institute (UK) and the Technology University of Delft (Netherlands) after the project was initiated in 2008 by Urenco. It is being developed by a consortium of Amec Foster Wheeler, Cammell-Laird, Laing O'Rourke and Urenco.

The consortium aims to have a demonstration reactor operating by 2025, and estimates that by the 4th-of-a-kind unit, U-Battery's capital costs will be between £40 and £70 million ($49 and $86 million).

Bruce Power Earns Top Award from Ontario Chamber of Commerce

The Ontario Chamber of Commerce has presented it's top business award to Bruce Power. The company has been named the 2016 recipient of the Ontario Business Achievement Award for Sustainability.

The return to service of four dormant nuclear units by Bruce Power between 2003 and 2012 provided 70 per cent of the power the province needed to shut down the coal stations, dramatically improving the quality of Ontario's air. It also added 3,000 megawatts of carbon-free electricity to Ontario's grid. The Sustainability Award goes to a business that has demonstrated that being a leader in sustainability makes good business sense.

"We are honoured and frankly humbled to receive this award and we accept it on behalf of our 4,000 employees who proudly make it their mission each and every day to safely provide the province with clean, reliable, low-cost electricity while at the same time maintaining a healthy environment," said James Scongack, Vice President of Corporate Affairs at Bruce Power.

"Closing coal-fired power plants represents one of the largest greenhouse gas reduction initiatives in North America," said Mr. Scongack. "'The closures have eliminated more than 30 megatonnes of annual GHG emissions, which is equivalent to taking seven million vehicles off Ontario's roads."

L3 MAPPS Wins Contract for Bruce Unit 6

L3 MAPPS announced that it has won a contract from Bruce Power to replace the existing Bruce B Unit 6 Digital Control Computer (DCC) system with all-new hardware. Three DCCs will be delivered to Bruce Power. The first unit (DCC-Z) will be used as a maintenance

platform and is due to be installed in the first quarter of 2018. The other two DCCs (DCC-X and DCC-Y) are redundant units for plant operations and are expected to be delivered in the second quarter of 2019.

DCC systems are used to monitor and control the major reactor and power plant functions at CANDU* nuclear power plants. The new DCC system will feature the latest SSCI-890 CPUs and will replace the legacy Varian V72 computer systems and related equipment to ensure continuous, safe and reliable performance over the service life of the plant.

SNC-Lavalin Awarded Refurbishment Contracts for Bruce

SNC-Lavalin (TSX:SNC) announced that it has been awarded contracts worth almost $28 million from Bruce Power, in support of Bruce's Major Component Replacement (MCR) project over the last three months.

Under two of four discreet contracts, SNC-Lavalin's Nuclear team, based in Mississauga, ON, will perform significant engineering scopes for detailed design of fuel channel and feeder reactor components. The design of these core components will enable the reactors, staring with Unit 6 and applicable to the remaining units, to continue to produce safe, reliable and affordable carbon-free power for another 30 years.

Under the third contract SNC-Lavalin will provide engineering, procurement and project management support services to assist Bruce Power in delivering automated and manual tooling to remove and reinstall fuel channel reactor components.

Finally, Bruce Power awarded SNC-Lavalin a contract for preliminary design of visual inspection and vacuuming tools which will be used by Bruce Power to clean and inspect the internal structure of the calandria vessel, providing assurance all components are fit for use to continue generating power.

BWXT Receives Expanded Contract for Bruce Refurbishment

BWXT Canada says its contract to provide services to the Bruce Power nuclear plant near Kincardine has been expanded to the tune of $30 million.

The Cambridge-based company said Wednesday that it will provide feeder inspection services under an expansion of a master services agreement that went into effect Jan. 1.

That agreement, announced in November 2014, involves providing engineering, tooling development, skills training and servicing of steam generators and preheaters at the power plant over a six-year period. It was valued at about $300 million.

Ontario Energy Minister Glenn Thibeault and BWXT President John MacQuarrie.

BWXT, formerly Babcock & Wilcox Canada, said the additional work involves inspections during scheduled maintenance outages of feeder pipes that carry coolant to and from the reactor core. The work, which includes the training of staff, will begin this year, it said.

Three New Commissioners Appointed to CNSC

The Canadian Nuclear Safety Commission (CNSC) is pleased to announce that the Governor in Council has appointed three part-time, permanent members to the CNSC on an interim basis for a term of one year.

The CNSC welcomes Dr. Sandor Jean Demeter, a nuclear medicine physician (Winnipeg, MB); Dr. Soliman A. Soliman, a mechanical engineer (Mississauga, ON); and Rob Seeley, a chemical engineer (Fernie, BC).

Cameco granted 10-year Licence Renewal for Port Hope

Cameco Corporation has been granted a 10-year operating licence for its conversion facility in Port Hope, Ontario by the Canadian Nuclear Safety Commission (CNSC). The new licence expires on February 28, 2027.

"We are very pleased that the CNSC has accepted our application for a 10-year operating licence," said Dale Clark, vice-president of Cameco's fuel services division. "The decision demonstrates the commission's confidence in our ability to safely produce and protect the environment at this facility both now and far into the future."

The licence was granted after an in-depth public hearing process which occurred in Port Hope in November, 2016. Members of the public were invited to voice their support or concerns about the continued operation of the facility.

L3 MAPPS Wins South African Simulator Contract

L3 MAPPS announced that it has signed a contract with Eskom Holdings SOC Limited (Eskom) to perform a multi-phase project to prepare the two Koeberg Power Station operator training simulators for the steam generator replacement that is taking place on the actual plant units.

"We have been supporting Eskom since 2002 and have thoroughly enjoyed working together on interesting and challenging projects that deliver innovative technological solutions," said Michael Chatlani, Vice President of Marketing & Sales for L3 MAPPS Power Systems and Simulation. "We are very pleased to continue our collaboration with Eskom as we roll out this new project."

Nuclear Plant Closures Drove Up Emissions in California

Carbon emissions from California's electricity generation are two-and-a-half times higher today than they would have been if the state had kept open nuclear power plants forced to close prematurely and not abandoned plans for new units, according to a new analysis by the Environmental Progress (EP) research and policy organization.

Based on data from the California Air Resources Board and the California Energy Commission, and assuming natural gas as a replacement for nuclear, EP calculates that the state's 2014 emissions were 30.5 million tonnes higher than they would have been had the Rancho Seco and San Onofre plants remained open and had five further units been built as planned.

"Had those plants been constructed and stayed open, 73% of power produced in California would be from clean (very low-carbon) energy sources as opposed to just 34%. Of that clean power, 48% would have been from nuclear rather than 9%," the organisation said.

Siemens Prints a Part for Krsko

3D-printed impeller has been in use in a pump at Slovenia's Krško plant since January. Siemens, which produced the component, said this marks "the first successful commercial installation and continuing safe operation" of such a part in a nuclear power plant.

Plant operator Nuklearna Elektrarna Krško (NEK) required a replacement metallic, 108mm-diameter impeller for a fire protection pump that is in constant rotating operation. The orginal part had been in operation since the plant was commissioned in 1981. However, the manufacturer of that part is no longer in business.

3D-printed impeller for Krsko.

Siemens said its team of experts in Sloveina reverse-engineered and created a "digital twin" of the part. A 3D-printed replacement part was then produced at the company's additive manufacturing facility in Finspång, Sweden.

UNSCEAR releases study on radiation exposure from electricity

Public exposure to radiation resulting from the generation of electricity by nuclear power plants is just a fraction of that from coal-powered plants, according to a report from the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).

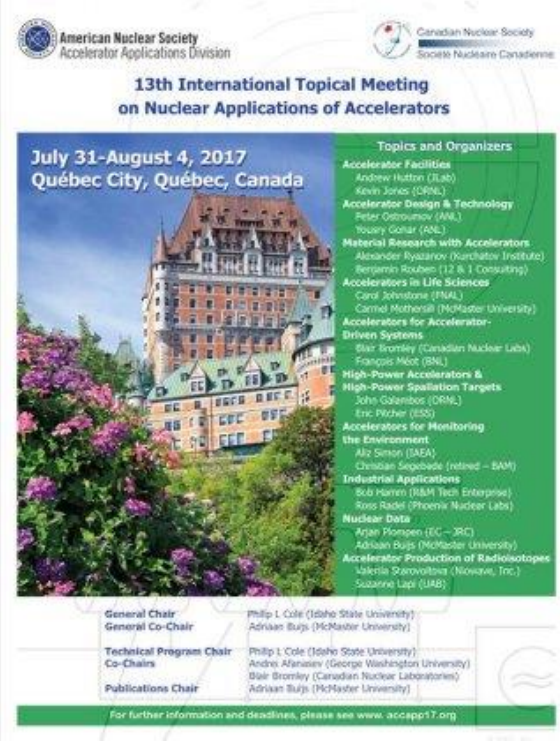
The previous such study was published by UNSCEAR in 1993. The committee said it had updated its methodology for estimating public exposures due to radioactive discharges. It says the new methodology is "more flexible to be able to address a wide range of electricity-generating technologies." The committee has also re-evaluated occupational exposures arising from different generating technologies, using data mainly from dosimetry records of worker exposures.

UNSCEAR released on February 8 the results of a comparative study it has conducted of exposures from generating technologies based on nuclear power, coal, natural gas, oil, biofuels, geothermal, wind and solar.

The committee said that while exposure levels are very low, the coal cycle contributed more than half of the total radiation dose to the global population from electricity generation. The nuclear fuel cycle, it said, contributed less than one-fifth of this. The collective dose for coal generating technologies is 670-1400 man Sieverts, depending on the age of the power plant, while that of nuclear is 130 man Sv. This is followed by geothermal at 5-160 man SV, natural gas at 55 man Sv and oil at 0.03 man Sv.

American Nuclear Society
Accelerator Applications Division

Dear Colleagues,



AccApp'17 is the thirteenth international topical meeting on the applications of accelerators; it is being organized by the Accelerator Applications Division of the American Nuclear Society (ANS) and the Canadian Nuclear Society (CNS). **AccApp'17 will be held at the Hilton Québec Hotel, in Québec City, Québec, Canada July 31-August 4, 2017.**

The purpose of these topical AccApp meetings is to provide an international forum for discussing the various applications of particle accelerators. Meetings are focused on the production and utilization of accelerator-produced neutrons, photons, electrons and other particles for scientific and industrial purposes; production or destruction of radionuclides significant for energy, medicine, defense, or other endeavors; safety and security applications; medical imaging, diagnostics, and therapeutic treatment.

One of the great strengths of the AccApp meetings is the dissemination of knowledge on the diverse applications of accelerators. The conference provides an opportunity for nuclear physicists, accelerator physicists, nuclear engineers, and other experts in the international community to meet and discuss their research face-to-face. These interactions can help establish good working relationships and collaborations to solve common problems across multiple disciplines. Also, old friendships can be cultivated and new ones established.

You are cordially invited to participate in AccApp'17 by submitting an abstract, making an oral or poster presentation, and submitting a full paper for publication in our conference proceedings. For further information (including deadlines and registration), please see the conference webpage at www.accapp17.org. The deadline for abstract submission (200 word limit) is March 31, 2017.

Full papers (10 pages or less) are due on September 10, 2017. For each extra page beyond 10 pages, there will be charge of $100 per page. The templates for both the abstract and the full paper can be found on www.accapp17.org. The downloadable high-resolution poster can be found on www.accapp17.org.

We are looking forward to seeing you in la belle ville de Québec!

Philip Cole (colephil@isu.edu)
General Chair of AccApp'17

Adriaan Buijs (buijsa@mcmaster.ca)
General Co-Chair of AccApp'17

American Nuclear Society
Accelerator Applications Division

Canadian Nuclear Society
Société Nucléaire Canadienne

13th International Topical Meeting on Nuclear Applications of Accelerators

Topics and Organizers

Accelerator Facilities
Andrew Hutton (JLab)
Kevin Jones (ORNL)

Accelerator Design & Technology
Peter Ostroumov (ANL)
Yousry Gohar (ANL)

Material Research with Accelerators
Alexander Ryazanov (Kurchatov Institute)
Benjamin Rouben (12 & 1 Consulting)

Accelerators in Life Sciences
Carol Johnstone (FNAL)
Carmel Mothersill (McMaster University)

Accelerators for Accelerator-Driven Systems
Blair Bromley (Canadian Nuclear Labs)
François Méot (BNL)

High-Power Accelerators & High-Power Spallation Targets
John Galambos (ORNL)
Eric Pitcher (ESS)

Accelerators for Monitoring the Environment
Aliz Simon (IAEA)
Christian Segebade (retired – BAM)

Industrial Applications
Bob Hamm (R&M Tech Enterprise)
Ross Radel (Phoenix Nuclear Labs)

Nuclear Data
Arjan Plompen (EC – JRC)
Adriaan Buijs (McMaster University)

Accelerator Production of Radioisotopes
Valeriia Starovoitova (Niowave, Inc.)
Suzanne Lapi (UAB)

General Chair	Philip L Cole (Idaho State University)
General Co-Chair	Adriaan Buijs (McMaster University)
Technical Program Chair	Philip L Cole (Idaho State University)
Co-Chairs	Andrei Afanasev (George Washington University)
	Blair Bromley (Canadian Nuclear Laboratories)
Publications Chair	Adriaan Buijs (McMaster University)

For further information and deadlines, please see www. accapp17.org

Publications

The IAEA is pleased to announce the publication of:

Evaluation of the Status of National Nuclear Infrastructure Development

IAEA Nuclear Energy Series No. NG-T-3.2 (Rev. 1)

This publication provides a holistic approach to evaluate progress in the development of the nuclear power infrastructure based on the guidance contained in the IAEA Nuclear Energy Series No. NG-G-3.1, Milestones in the Development of a National Infrastructure for Nuclear Power. It can be used by a Member State itself, wishing to evaluate its progress (self-evaluation), or as a basis for an integrated nuclear infrastructure review (INIR) mission. This revised version combines in one document an explanation of the methodology and the evaluation tables, takes into account all new material and lessons learned from the Fukushima Daiichi accident, and presents the results of the INIR missions implemented between 2009 and 2014.

STI/PUB/1737, 69 pp.; 1 fig.; 2016; ISBN: 978-92-0-102316-2, English, 29.00 Euro

Electronic version can be found:

http://www-pub.iaea.org/books/iaeabooks/10955/Evaluation-of-the-Status-of-National-Nuclear-Infrastructure-Development

Country Nuclear Power Profiles

The Country Nuclear Power Profiles compile background information on the status and development of nuclear power programmes in Member States. The publication summarizes organizational and industrial aspects of nuclear power programmes and provides information about the relevant legislative, regulatory and international framework in each State. Its descriptive and statistical overview of the overall economic, energy and electricity situation in each State and its nuclear power framework is intended to serve as an integrated source of key background information about nuclear power programmes throughout the world. This 2016 edition, issued on CD-ROM, contains updated country information for 51 States.

CD Edition (2016); ISBN: 978-92-0-156916-5, IAEA-CNPP/2016/CD, English, 95.00 Euro

Electronic version can be found:

http://www-pub.iaea.org/books/IAEABooks/11127/Country-Nuclear-Power-Profiles

The Canadian Nuclear Society presents a course for anyone communicating about nuclear:

Nuclear 101

Everything you wanted to know about nuclear technology and were afraid they'd ask!

2017 May 1 & 2
Ottawa, Ontario
Courtyard Marriott Ottawa East & Conference Centre
200 Coventry Road, Ottawa, ON K1K 4S3

The two-day **Nuclear-101** course is specifically designed for individuals (including students) within the nuclear community (with or without a technical background) who find themselves interacting with the public. The course will provide you with a good understanding of nuclear and energy fundamentals, along with the tools to explain to others in simple, factual terms how the technology works, some of the interesting twists and turns of its exciting history, and the important contribution nuclear science and technology makes to our society.

The course will be taught by three of Canada's leading nuclear educators, Doug Boreham, Benjamin Rouben and Jason Donev It will consist of three modules, and will include demonstrations, Q&A, and a discussion of each module's relevance to public outreach:

- Energy and the Nuclear Fuel Cycle
- Facts, Myths, and Historical Review of the Nuclear Industry
- Health Risks of Radiation

Who should register:

- Anyone in the nuclear community who regularly speaks to the public (or is interested in speaking to the public) and would like to be able to explain nuclear technology in simple, factual terms.
- Anyone who has ever been asked "difficult" questions about the past, present, and future of the industry – and wishes he/she knew the answer.
- Anyone who would like to broaden his/her knowledge about Canadian nuclear science and technology: its history, current status and future potential.

How to register:

This outreach course is being offered by the Canadian Nuclear Society (CNS). You may register via the link on the course webpage: http://www.cns-snc.ca/events/nuclear-101-2017. The cost of the 2-day course is $495 (HST included), and will cover all materials. **Full-time university students may register at a discounted rate of $300 (HST included)**. Register early to avoid disappointment.

Venue and Accommodations:

The course will be held at the Courtyard Marriott Ottawa East and Conference Centre, 200 Coventry Road, Ottawa, ON, K1K 4S3. Guestrooms may be reserved on the Nuclear-101 dedicated website: https://aws.passkey.com/event/49060285/owner/11893515/home, or by calling the Courtyard Ottawa East at 1-613-741-9862 and requesting the rate for the Canadian Nuclear Society course. Reserve early to avoid disappointment!

Join us in Niagara Falls for the:

37th CNS Annual Conference and the 41st CNS-CNA Student Conference

Sheraton on the Falls Hotel

June 4-7, 2017

"Our Nuclear Future: Renewal and Responsibility"

Your Registration Fee Includes:

- **Exciting plenary sessions**
- **A wide-ranging technical program**
- **Opening Reception, Breaks, Luncheons**
- **Banquet at "Queen Victoria Place"**
- **Wine-&-Cheese at Student Posters**
- **Canadian Nuclear Achievement Awards**
- **Networking opportunities and more!**

Who should attend? YOU!

The CNS Annual Conference and Student Conference gathers scientists, engineers, technologists, senior management, government officials, and students, interested in nuclear science and technology, from across Canada and other countries!

www.cns2017conference.org

Conference Host Sponsor:

Bruce Power

Calendar

2017

April 25-27 — **World Nuclear Fuel Cycle**
Delta Toronto Hotel
Toronto, Ontario
nei.org/conferences/upcoming-conferences

May 1-2 — **CNS Nuclear-101 Course**
Mariott Courtyard Ottawa East,
Ottawa, ON
cns-snc.ca

June 4-7 — **37th CNS Annual Conference & 41st CNS/CNA Student Conference**
Sheraton on the Falls Hotel
Niagara Falls, ON
cns2017conference.org/

June 11-15 — **ANS Annual Meeting**
San Francisco, CA, USA
ans.org/meetings

July 31-Aug. 4 — **13th International Topical Meeting on Nuclear Applications of Accelerators (AccAPP17)**
Hilton Quebec Hotel,
Quebec City, QC
accapp17.org

Sept. 17-20 — **2nd CNS Conference on Fire Safety and Emergency Preparedness for the Nuclear Industry**
Toronto Marriott Downtown
Eaton Centre Hotel
Toronto, ON
cns-snc.ca/events/2cfsep/
cns-snc@on.aibn.com

Sept. 24-27 — **Global 2017 International Fuel Cycle Conference**
Sheraton Grande Walkerhill
Seoul, South Korea
global2017.org/congress/index3.php

October — **CANDU Fuel Technology Course**
Hilton Garden Inn Toronto/Ajax
Ajax, ON
cns-snc.ca/events

October 1-4 — **CANDU Maintenance & Nuclear Components Conference (CMNCC)**
Toronto Mariott Down
Eaton Centre Hotel
Toronto, ON
cns-snc.ca/events/cmncc-2017/

Fall — **CANDU Thermal Hydraulics Course**
Toronto, ON
cns-snc.ca

Nov. 12-16 — **2017 ANS Winter Meeting and Nuclear Technology Expo**
Washington, DC, USA
ans.org/meetings/c_1

2018

February — **CNA Nuclear Industry Conference and Tradeshow**
Westin Hotel
Ottawa, Ontario
cna.ca/2018-conference

March — **CANDU Technology & Safety Course**
cns-snc.ca

April 22-26 — **PHYSOR 2018**
Cancun, Mexico
physor2018.mx

May 2018 — **Nuclear 101**
cns-snc.ca

June 3-6 — **38th Annual CNS Conference & 42nd Annual CNS/CNA Student Conference**
Sheraton Cavalier Hotel
Saskatoon, SK
cns2018conference.org

June 17-21 — **ANS Annual Meeting**
Philadelphia, PA
ans.org/meetings

Sept. 30-Oct. 3 — **PBNC 2018**
San Francisco, CA, USA
pacificnuclear.net/pnc/pbnc
ans.org/meetings/c_2

Fall — **Waste Management, Decommissioning and Environment Restoration for Canada's Nuclear Activities**
cns.snc.ca

Fall — **International Conference on Simulation Methods in Nuclear Engineering**
cns-snc.ca

Fall — **International Technical Meeting on Small Reactors**
cns-snc.ca

Nov. 11-15 — **2018 ANS Winter Meeting**
Orlando, FL, USA

2019

February — **CNA Nuclear Industry Conference and Tradeshow**
Westin Hotel
Ottawa, Ontario
cna.ca/2019-conference

March — **CANDU Technology & Safety Course**
cns-snc.ca

May — **Nuclear 101**
cns-snc.ca

June — **39th Annual CNS Conference & 43rd Annual CNS/CNA Student Conference**
cns2019conference.org

11th International Conference on CANDU® Maintenance and Nuclear Components

Delivering **Clean Energy** through CANDU® Life Extension

October 1-4, 2017 · Toronto Marriott Downtown Eaton Centre Hotel · Toronto, ON Canada

CALL FOR PAPERS

The CMNCC 2017 Technical Program Committee invites the submission of 300-word abstracts of papers pertaining to the technical focus of the conference. Abstracts covering, but not limited to, the following topics will be considered for presentation.

CANDU® Refurbishments

Benchmarking Programs
- Performance
- Maintenance
- Component Degradation and Life Management

Operational Experience (OPEX)
- Degradation of Major Components
- Lessons Learned
- Best Practices

Aging Management and Equipment Reliability
- Pump Motors and Pump Seals
- Heat Transport System and feeders
- Steam Generators and Heat Exchangers
- Fuel Channels
- Inspection Tooling
- Instrumentation & Control

Power Derating Mitigation
- NOP/ROP – Extreme Value Statistics (EVS)
- Reactor Inlet Header Temperature Reduction
- Steam Generator Cleaning
- 37 M and other Fuel-Design Strategies

Post-Fukushima Strategies
- Emergency Mitigation Equipment (EMS)
- Hydrogen Mitigation
- Containment Exhaust Venting

Succession Planning & Attracting Young Professionals to the Industry

Abstract Submissions

Abstracts of proposed presentations are to be no more than 300 words in length and are to be submitted online through the link on the Call for Papers page of the conference website.

The deadline for abstract submission is **June 1, 2017**.

Conference Proceedings

Submission of full papers for the Conference Proceedings is preferred, however as a minimum speakers' PowerPoint slide presentations are required for inclusion.

Author Notification

All abstracts will be formally reviewed and assessed by the Technical Program Committee and presenters will be notified of the results of the Committee's review by June 15, 2017.

Important Dates

Abstract submissions due	June 1, 2017
Author notification of review results	June 15, 2017
Draft papers/presentations due	July 14, 2017
Early registration deadline	July 31, 2017
Final paper/presentation acceptance	August 18, 2017
Hotel reservation cut-off date	August 30, 2017
CANDU Configuration Overview Course	October 1, 2017
The Conference	October 1-4, 2017

Hotel Accommodation

The Toronto Marriott Downtown Eaton Centre Hotel is the conference location and official provider of accommodation for CMNCC 2017 participants. A block of rooms is available at the preferred rate of $249/night plus taxes. Reservations can be made through the link on the Hotel Accommodation page of the CMNCC website or by calling Marriott Reservations at 1-800-228-9290 and providing the group code: **Canadian Nuclear Society**.

Toronto Marriott Downtown Eaton Centre Hotel
525 Bay Street, Toronto, ON M5G 2L2

Reservations

Marriott Reservations: 1-800-228-9290
Hotel Direct: (1) 416-597-9200

Organized and sponsored by the Canadian Nuclear Society – Nuclear Operations and Maintenance Division

For everything you need to know about CMNCC 2017 go to
www.cmncc2017.org

2016-2017 CNS Council • Conseil de la SNC

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Would I prefer Windmills or an SMR in my backyard

by NEIL ALEXANDER

At a Small Modular Reactor (SMR) Conference recently a popular question for the presenters was "but would you have one in your backyard". This is a classic out of context question that compares nuclear with a perfect world in which electricity does not need to be generated. It struck me that a better question would be "would you prefer a windmill or a nuclear power plant in your backyard".

To be clear I am thinking of a metaphorical backyard not my actual one. My backyard isn't big enough for either and anyway I strongly suspect the neighbours would complain. I assume we mean in direct view, close by, within sniffing distance, something along those lines.

This is a question that can't be answered by data review; it needs personal experience.

Now I must say that I would not like look out onto a big nuclear plant because they are industrial complexes where for some 60s/70s/80s reason we forgot to employ architects. If you work for Bruce Power or OPG and you love your nuclear unit then I apologize but you have to appreciate they are the kind of babies that only the parents could find attractive.

But that is not the issue. The issue is would you prefer a windmill or a SMALL reactor and on this I can comment because I have been working with SMR companies, have lived in and around nuclear reactors all my adult life (comes with the job) and also now have windmills (lots of them) in my "backyard".

This is then my personal comparison.

My current view

- No worrying emissions
- Sufficiently far away for noise not to be a problem (is apparently a problem for people closer to them)
- Sufficiently far away for them not to create a strobe affect out of sunlight (this is a problem for people living closer)
- Tall visually unpleasant destroyers of the view and in this case beautiful sunsets
- The blades of the closer ones move irritatingly in and out of your peripheral vision constantly giving you a panic response that you may be about to be attacked by a lion
- Adds no value to the community and because they reduce quality of life they lower property values
- Dangerous to people that live nearby as they have a tendency to catch fire, fall over or both

Potential view of a modern SMR

- No worrying emissions
- Sufficiently far away for noise not to be a problem (no problem no matter how close people get)
- No affect on sunlight whatsoever
- Attractive,low lying and barely noticeable
- Static on the outside
- Adds value to the community by creating high quality job opportunities that could easily give rise to an increase in property values
- Aspects of inherent safety that mean I have no concerns about safety

No contest I would take the SMR.

This brings me to one of life's big paradoxes, that as you approach a nuclear plant support for nuclear goes up. On the other hand, as you approach windmills their popularity drops.

And an SMR would produce large quantities of power on a tiny footprint so affecting very few backyards while windmills need a huge footprint. If you live on the Niagara peninsula you will know the whole region now looks like it has been invaded by the Martian machines from War of the Worlds. It is even worse elsewhere.

I would though miss one thing about my windmills. Typically, they start each day at a standstill, but around 2pm they rotate to face the lake and shortly thereafter the wind picks up. This tells me when to get my boat out and go for a sail. But to be honest I could also just wander outside and check the wind for myself.

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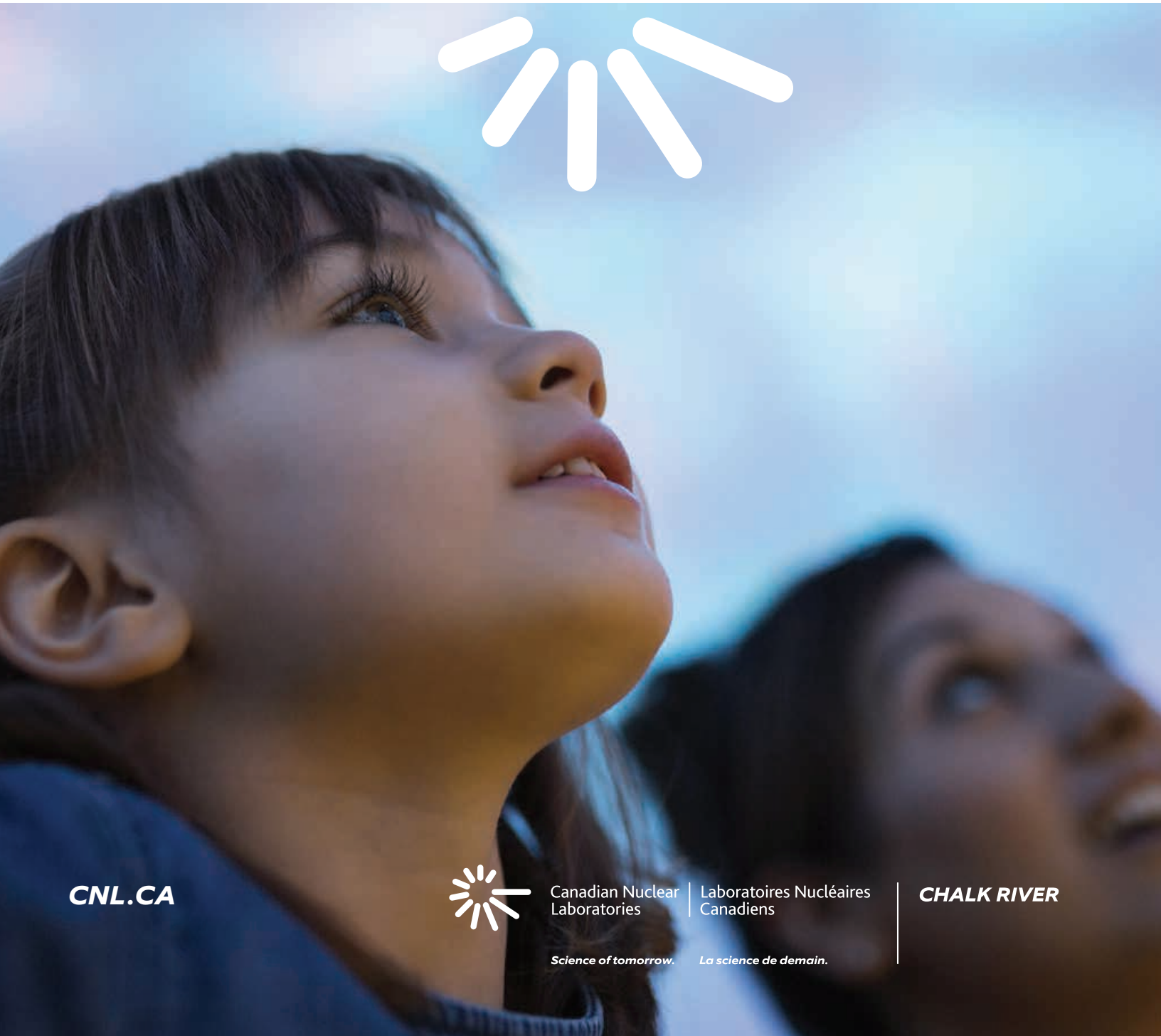

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