CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

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- 2016 Annual CNS Conference Review
- CNS/CNA Honours and Awards
- History: The Toronto Radiation Scare of 1961
- New CNS Council Elected

Yellowknife Citizens Tell Nuclear Advocate to "GO HOME"

When a representative from Terrestrial Energy attended an information forum in Yellowknife on what seemed to be a pleasant evening last May, he intended to explain and answer questions about the advantages of bringing nuclear energy to Canada's North, an alternative to the highly polluting and extremely high cost electricity currently generated using diesel. Instead, he was greeted with hostility, repeatedly shouted down and told to "Go home!" As reported by the CBC, the Ontario-based company attempted to present a new design of a nuclear reactor, using a new, safer technology; it will use Molten Salt instead of traditional water-cooled uranium fuel bundles. Instead of cooling radioactive rods with water, it dissolves nuclear fuel in molten salt, making the fuel its own coolant.

The advantages of using the salt as a coolant are that much less plutonium is produced, which simplifies needed safeguards requirements and waste management, and significantly reduces the risk of a reactor meltdown. It is also relatively small (modular design) and quite compatible with far-north electricity grid constraints. There are many other technical advantages, but to the lay person they are nothing more than well articulated mumbles.

Kevin O'Reilly, an MLA from nearby Frame Lake, was slightly better informed than the local residents, and asked the usual questions: what about the waste?, where has this technology been used?, how will it be financed? O'Reilly also expressed doubt that the new technology could be safely regulated, according to the CBC. These concerns were just small stuff, red herrings in perspective to the bigger picture of things.

The Terrestrial Energy representative was obviously blind-sided, a sucker-punch if you will, since the town's hostility he encountered had absolutely nothing to do with him, his corporation or even nuclear technology! Aside from the typical politician concerns (safety, waste, financing, first-of-a-kind technology) the local residents had something else driving their angst, unrelated to nuclear technology.

Residents of the North West Territories are mostly aboriginal, and the Yellowknife attendees were predominantly Dene. They shouted "What about Dehcho?"

So what about Dehcho? Good question, something we need to be more attuned with as Canadians. The Dene of the Dehcho have lived in their ancestral territories and waters according to their own laws and system of government since time immemorial. The Dehcho Dene were put there "by the Creator as keepers of our waters and lands."

The chant is similar to the famous "What about the Alamo?" To the Dene, it refers to the exploits of Giant Mine, or perhaps all Canadians, that extracted gold from the area and left in return a legacy of toxic waste, mostly arsenic trioxide (with fibrous asbestos as well), the stuff that was thrown away after all the gold was extracted. The Government of Canada is now assisting with remediation, but it may never restore the land and waters to their former pristine life. The Dene are upset, justifiably so, and may never trust the help of corporations again, no matter how ethical a company claims to be. There are too many similar fiascos of Corporations contaminating native lands and waters in the name of profit, taking the valuable resources and leaving the garbage behind.

With all good intentions, for the benefit of the people and the planet, a small forum of information sharing ended with a major communication meltdown. No doubt, the representatives of Giant Mine (or its predecessors) sold the local community with the advantages they wanted at the time - jobs, wealth, prosperity, better schools and hospitals) but they did not ask the probing questions, or were not given honest answers, at the time. This time, another corporate representative has shared information at a small community forum, but the people have remembered. They were lied to once, and may never trust another attempt, at least not without a lot of effort to gain the trust and respect that is needed if new projects are to be accepted on aboriginal lands.

Next time, if there is a next time, the nuclear community needs to do its homework. Perhaps they need to live in the community in which a proposal is to be made, to understand the lay of the land, and the feelings of the people. Politicians often assume that their constituents have short memories; not so with aboriginal peoples. Memory is how they promulgate their traditional way, their means of mass communication from generation to generation, and people need to understand and respect their heritage. That should be easy - the Dehcho have their own web-site! But go and spend some face time with them!

In This Issue

The annual CNS Conference was another success this year and we have an excellent account of the highlights, including a special report on the CNS/CNA Honours and Awards. There is also an excellent account of a radiation scare that happened in downtown Toronto, more than 50 years ago, which did not seem so scary at the time, but would have been a major catastrophe if it happened today (even though, from a health perspective, it was minor).

Two letters were received, for which I am thankful, and encourage many more. There is also a conversation with an old friend, in Jeremy Whitlock's Endpoint.

Enjoy the summer while we actually have one this year, and remember to drive and swim safely!

From The Publisher

The CNS Annual Conference, held on June 19-22, 2016, showed the strength of both the Canadian Nuclear Society and the strength and scope of Canada's nuclear industry. At its Annual General Meeting, the CNS elected a new Council for the next 12 months to govern its affairs. What is striking about the new Councilors is the youth and variety of backgrounds of the Council now.

Many were involved in the organization of the Annual Conference, as noted elsewhere in this Bulletin. They see the Society as an organization of great value to them, a place to meet with those who have gone before them to build or operate the institutions in which the new generation now finds itself.

With its exhibitors, plenary speakers and technical program, the Annual Conference also showed the full scope and depth of Canada's nuclear industry. At the Conference, a wealth of nuclear technology was on display by the exhibitors. The plenary sessions revealed the large sweep of nuclear developments by Canadian science and technology, both in Canada and around the world. Just as important, the technical sessions displayed the detailed, world-leading science and engineering which is being done right here in Canada.

All of these are having real results in the real world. Just to take one example, the decisions made by the Ontario government late last year mean that Ontario will continue to have most of its electricity come from nuclear power past the mid-point of this century.

Global activity shows a similar picture. As noted in the 2016 edition of CNS Nuclear Canada Yearbook, there are 570 nuclear reactor projects around the world, one and a half times as many as actual reactors in service today. Some of these are under construction, some of these are planned, and some are still just in the proposal stage. But they are all taking place in countries with real needs for new electricity supply.

But our industry exists in a world clouded by illusion. The past seven months has seen several proclamations by national or world leaders of agreements intended to lead us to a new nirvana of trouble-free electricity supply.

The first such was the Paris Accord agreed at the 2015 COP conference of the UNFCCC (United Nations Framework Convention on Climate Change). Countries made solemn commitments to phase out the use of fossil fuels. Less than six months later, the Paris Accord is a dead letter. In June, a government document uncovered by Reuters showed that Germany was abandoning any timetable for phasing out coal-fired generation, and it was also abandoning any policy supporting a floor price for carbon.

A second such illustration came from the state government of California this June. The government, the owning utility, and the labour union agreed to the closure of California's only nuclear power station, the two reactors at Diablo Canyon. It was proclaimed that its non-emitting electricity would be replaced by emission-free electricity from renewables.

There are two interesting points to consider here. The first is that California's largest solar power installation at Ivanpah is listed as a major CO2 emitter on the state's registry. The second will be how IBEW (International Brotherhood of Electrical Workers) explains its leadership's sell-out of union member jobs at Diablo Canyon to its membership.

The final example comes from the meeting of the Three Amigos in Ottawa in mid-July. The three leaders proclaimed their interest in pursuing renewable generation, to convert North America to having half its electricity coming from renewable sources. There's just a small problem with the fact that with less than six months remaining in his term in office, President Obama has no power to commit the United States to anything at this time, let alone a fundamental transformation of his country's electricity supply.

What is equally interesting is that the one issue of substance on that table between Canada and the United States, the lapsed softwood lumber agreement, there was no agreement to renew or re-negotiate it.

It's no wonder the public is confused. It's forced to live in a world surrounded by a cloud of mis-information from government and media about what is actually happening about things like energy supply. This is a place where illusion is treated as reality, while reality is ignored.

And so we come to the final contrast. There's the illusion of statements and proclamations that clutter the news that comes to us. Then there's the truth about how things really work. That's a truth that is only discovered by coming to events like the CNS Annual Conference.

C.G.H.

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~ Cover Photo ~

Pickering Nuclear Generating Station.

Photo courtesy of Ontario Power Generation

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CNS provides Canadians interested in nuclear energy with a forum for technical discussion. For membership information, contact the CNS office, a member of the Council, or local branch executive. Membership fee for new members is $82.40 per calendar year, $48.41 for retirees, free to qualified students.

La SNC procure aux Canadiens intéressés à l'énergie nucléaire un forum où ils peuvent participer à des discussions de nature technique. Pour tous renseignements concernant les inscriptions, veuillez bien entrer en contact avec le bureau de la SNC, les membres du Conseil ou les responsables locaux. Les frais d'adhésion par année de calendrier pour nouveaux membres sont 82.40$, et 48.41$ pour retraités.

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Canada's nuclear industry strong and growing:

36th Annual CNS Conference

by COLIN HUNT

Paul Thompson opens the Annual Conference.

The strength of Canada's nuclear industry was shown clearly at the 36th Annual CNS Conference, held in Toronto from Sunday, June 19 to Wednesday, June 22, 2016 in Toronto. The Annual Conference was held in conjunction with the 40th CNS/CNA Student Conference, with 335 delegates, exhibitors and students in attendance.

The theme of the conference, 'Nuclear in the 21st Century: Global Directions and Canada's Role' was illustrated throughout the four days of the conference, showing the scope of nuclear industry activity in Canada and around the world.

Dr. Art McDonald

Canada's nuclear industry is about far more than power reactor construction and operation. It also includes basic research in high energy and astrophysics. A key highlight of the conference was the WB Lewis Lecture given by Dr. Arthur McDonald on Monday. Dr. McDonald and his team was the 2015 winner of the Nobel Prize for Physics for his work in building and operating the Sudbury Neutrino Observatory (SNO).

As noted in an earlier edition of the CNS Bulletin and in the 2016 edition of CNS Nuclear Canada Yearbook, the SNO project has been of vital importance in shaping human understanding of the universe around us and the physical properties of sub-atomic particles, in this case the neutrino. In his remarks, Dr. McDonald noted that a project such as SNO was only possible in Canada because of the need for very large quantities of heavy water for neutrino capture and observation.

Perhaps the most dramatic illustration of the scope and scale of the project came when Dr. McDonald posted the names of the hundreds of researchers who had contributed to and worked on the SNO project. After outlining the technical details of the project and its research results, Dr. McDonald noted the difficulty of communicating what SNO was about and what its research meant. After repeated requests by government to simplify the explanation, he observed, "This is probably the first time that basic particle physics has been illustrated using a box of Timbits."

Barclay Howden, CNSC

The opening plenary sessions on Monday, June 20 featured two strong panels. The first, chaired by Barclay Howden of the Canadian Nuclear Safety Commission (CNSC), featured the need for and challenges of introducing nuclear power in developing nations. Two presentations showed the contrasting challenges of large and small nations. The first by Djarot Wisnubroto, Chairman of the National Nuclear Agency of Indonesia, illustrated the problems of electricity supply in a very large, heavily populated nation distributed unevenly over hundreds of islands. With most of its population concentrated on the island of Java, this was the only useful location for any future nuclear power development.

Djarot Wisnubroto

His presentation included a number of surprising facts. The nation has an annual population growth of 1.4 per cent. Despite its reputation as an oil producing nation, Indonesia is now in fact a net importer of oil. Its population growth means that Indonesia has very strong and increasing demand for electricity, and availability of its principal fuel for electricity, natural gas, is limited.

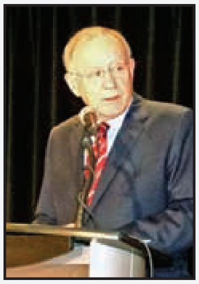
Mr. Wisnubroto noted that renewable forms of energy cannot possibly meet Indonesia's future energy demand, and that nuclear energy will be necessary to meet future needs. He noted that Indonesia has been engaged in site studies on the island of Java since 1991. He also observed that public support for nuclear power development is in excess of 75 per cent.

Charles Grant

The following presentation of Charles Grant, Director General, International Centre for Environmental Nuclear Sciences, Jamaica, illustrated an entirely different challenge faced by developing nations. Unlike Indonesia, Jamaica has experience with nuclear reactors with its SLOWPOKE research reactor. However, Jamaica has far too small a grid to make a conventional power reactor possible. He expressed strong support for the possibility of small modular reactor development in the future to relieve the island of reliance on diesel fuel for electricity generation.

Both speakers expressed strong approval of CANDU technology, and they agreed that it was under-promoted. Mr. Wisnubroto indicated that CANDU was originally the first technology considered because of its strong technical and safety performance. But it was subsequently dropped from consideration because of lack of promotion by the Canadian government and Indonesian interest shifted toward PWR technology.

In his remarks, Barclay Howden discussed the Convention on Nuclear Safety, adopted by the International Atomic Energy Agency (IAEA) in 1994. Mr. Howden noted that adoption of the Convention provided both peer review sharing of safety performance among current nuclear nations and could provide assistance and direction to developing nations seeking to establish nuclear power programs.



Dr. John Barrett

The second plenary session of Monday, June 20, focused on the development and future sustainability of Canada's nuclear industry, chaired by CNA President Dr. John Barrett. The panel covered a wide variety of topics including the future of nuclear research and development (Mark Lesinski, President of Canadian Nuclear Laboratories), the future of the Advanced CANDU reactor (Preston Swafford, Vice President, SNC Lavalin Inc.), the importance of nuclear safety culture (Ian Rowley, Vice President, Bruce Power), long term maintenance and operation of the CANDU fleet (Fred Dermarkar, President CANDU Owners Group), and the role of nuclear in a low carbon future (John Barrett, President of the CNA).

What the panel showed in sum was that Canada remains a world-leading nation in the operation and development of nuclear power reactor technology.

Tuesday afternoon featured two strong plenary sessions. The first was on innovations in health and nuclear medicine, chaired by Dr. Neil Alexander of the Sylvia Fedoruk Centre in Saskatoon. Six speakers: Neil Alexander, Andrew Ross, Francois Couillard, Paul Schaffer, Mark de Jong, and Joanne Grozelle, outlined the future of Canadian production of medical radioisotopes with the ending of supply from the NRU reactor in Chalk River in 2018. What these presentations showed was that Canada will remain a world-leading producer of both new nuclear technology and of production of radioisotopes long into the future after NRU has closed.

The second plenary of the afternoon, chaired by Dr. Jeremy Whitlock of Canadian Nuclear Laboratories (CNL), focused on communications by and within the Canadian nuclear industry. The speakers included Jason Cameron, CNSC, Robert Watts, Nuclear Waste Management Organization (NWMO), Katherine Ward, SNC-Lavalin, and Heather Kleb, Women in Nuclear Canada. The session included presentations on communications by Canada's nuclear regulator, communicating Canada's long term plan for used nuclear fuel disposal, showing the advantage of nuclear to reduce carbon emissions, and women in skilled trades in the nuclear industry.

Tuesday's last panel was followed by the Student Poster Competition, just prior to the Nuclear Industry Awards Banquet. Winners of the Student Poster Competition were: Jacqueline Williams, Undergraduate, University of Calgary; Edward Matt, Master's, McMaster University; and Jason Sharpe, PhD, McMaster University.

Dr. Robert Walker

The final plenary sessions of the conference came with two panels on Wednesday morning. The first chaired by Dr. Robert Walker, Past President of CNL, looked at future applications of advanced nuclear technologies. Of particular interest was the presentation of Peter Lang, showing the need for small modular nuclear reactors to alleviate reliance on diesel fuel for Canada's northern communities. Also of great interest was Roger Humphries outlining the activity of the Emissions-Free Energy Working Group, Neil Alexander discussing small modular reactors for use in communities, and Adrian Nalasco of the Ontario Ministry of Energy discussing the government's priorities for nuclear research and development.

Dr. John McKinnon

Dr. Peter Ozemoyah

The second and final plenary of the conference chaired by Ron Oberth, President of the Organization of Canadian Nuclear Industries (OCI), looked at opportunities for Canada's nuclear industry around the world.

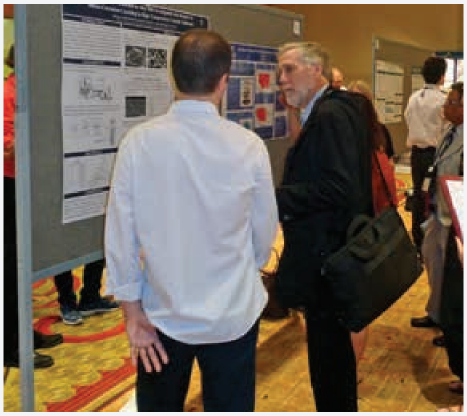
The 2016 conference was made possible by strong support from sponsors. These included Host Sponsor AMEC-Foster Wheeler, and sponsors CNL, Ontario Power Generation (OPG), CNSC, Kinectrics, the Power Workers Union (PWU), SNC-Lavalin, NB Power, NWMO, RCM Technologies, TetraTech, GE-Hitachi, ANRIC, Promation Nuclear, Stern Laboratories, Tyne Engineering, 12&1 Consulting, L3-MAPPS, OCI, Lakeside, and York Search Group.

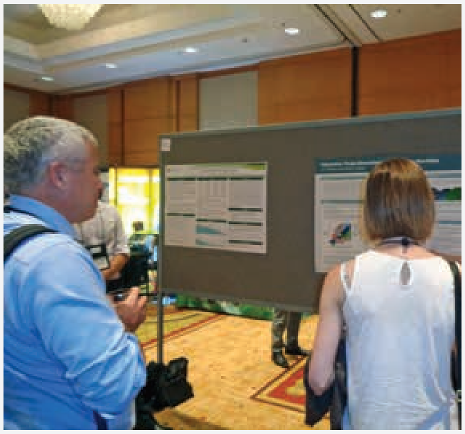
The conference had a strong organizing team consisting of: honorary chair Dr. John McKinnon, executive chair Dr. Peter Ozemoyah, plenary co-chairs Daniel

Brady and Frank Doyle, technical program co-chairs Dan Gammage and Lawrence Leung, student conference chair Dr. Adriaan Buijs, and student conference organizers Andrew Ali and Kendall Boniface. Also with the conference organizing committee were: treasurers Tracy Lapping, Mohinder Grover and Ken Smith, sponsors and exhibits Aman Usmani and Kris Mohan, publicity Jeremy Whitlock, honours and awards chair Ruxandra Dranga, facilities Dr. Ben Rouben, and NAYGN Devi Shantilal.

Organizing committee of the 2016 CNS Annual Conference: Back row: Paul Thompson, Lawrence Leung, Mohinder Grover, Jacques Plourde, Dan Gammage, John McKinnon, Peter Ozemoyah, and Adriaan Buijs. Front row: Andrew Ali, Dan Brady, Ruxandra Dranga, Tracy Lapping, Frank Doyle, Jeremy Whitlock and Kendall Boniface.

Student Poster Competition





2016 Canadian Nuclear Achievement Awards

by RUXANDRA DRANGA, CNS-CNA Honours and Awards Chair

On June 21, 2016, the CNS and CNA jointly recognized 40 recipients for their outstanding contributions within the Canadian Nuclear industry and the Canadian nuclear research and academic communities, during the 2016 Canadian Nuclear Achievement Awards. The awards ceremony was held in Toronto, Ontario, during the Canadian Nuclear Society Annual Conference. This year, awards were presented for seven out of the ten available award categories, to recipients who exemplify the expertise, innovation and commitment found across our industry. The awards were presented by Mr. Paul Thompson, CNS President (2015 – 2016), and Dr. John Barrett, CNA President.

Three **Harold A. Smith Outstanding Contribution Awards** were presented this year. The first award was presented **Mr. John Froats**. Mr. Froats' career spans over 40-years at Ontario Power Generation, where he held positions of increasing technical and managerial responsibility, culminating at the level of Chief Nuclear Engineer. Since 2011, Mr. Froats has been an Associate Professor and Nuclear Engineer in Residence at the University of Ontario Institute of Technology, where he has helped shape and deliver the Nuclear Engineering Program. Throughout his career, John has made significant contributions to OPG, CANDU Owners' Group, has led the Canadian Standards Association Nuclear Strategic Steering Committee for more than a decade, and has been a long-standing member of Canada's team to the IAEA.

The second award was presented to **Mr. Richard Hohendorf**. Mr. Hohendorf has been an acknowledged leader in digital systems development and application at Ontario Power Generation. His ground-breaking work in this area has influenced not only OPG, but the entire industry. Notably, Mr. Hohendorf was instrumental in implementing an innovative ageing management approach for the computers in OPG stations, which formed the basis for subsequent computer upgrades.

The third award was presented to **Mr. Stephen Yu**, who has worked for over 40-years at AECL and Candu Energy Inc., making significant contributions to the design and development of CANDU reactors through an evolving licensing landscape. Throughout his career, Mr. Yu published numerous papers on CANDU engineering and design, and has given talks and lectures in many workshops and seminars on CANDU product features and engineering. Following his retirement in March 2015, Mr. Yu continues as CANDU Product Development Engineer Emeritus, providing mentoring and technical guidance for the next generation of nuclear engineers.

Two **Innovative Achievement Awards** were presented this year: one individual award and one team award. The individual award was presented to **Dr. Sriram Suryanarayan**, a chemist working at Kinectrics Inc., where he developed a process to allow disposal of mixed liquid radioactive wastes via an economic and environmentally friendly process. Dr. Suryanarayan and his team also proposed design changes to address the challenges of in-service fluid quality and performance of the high-pressure pumping and treatment system. Through developing innovative solutions to waste management, Dr. Suryanarayan helped achieve significant savings for the Canadian power industry.

Dr. Gerard Moan, Mr. Syd Aldridge and Mr. Ronald Graham were awarded the team Innovative Achievement award for their development of zirconium alloys with very low initial concentrations of hydrogen. The nature of the team's achievement required the combined expertise of each recipient in specific areas of competency, since careful consideration had to be given to every aspect of component fabrication – from production of zirconium sponge, through melting and hot deformation. The results of the work were changes in the technical specification of pressure-tube material that reduced the maximum hydrogen concentration from 25 to 5 ppm. The significance of this large improvement is that replacement of pressure tubes can be postponed by several years, which is of great economic benefit to CANDU and the utilities.

The **John S. Hewitt Team Achievement Award** went to a large and **broad-based industry team** composed of recipients from **Amec Foster Wheeler, Bruce Power, Canadian Nuclear Laboratories, KHNP, SNN, NB Power, Ontario Power Generation, and Stern Laboratories**, for the development of the modified 37-element fuel bundle, coined the 37M fuel bundle. By replacing the centre element with a smaller diameter one, the 37M bundle design allows more coolant to flow through the bundle, resulting in greater temperature increase before the onset of Critical Heat Flux. The 37M fuel bundle design has been successfully introduced into CANDU power reactors, resulting in immediate and significant long-term cost benefits.

Mr. Daniel Brady received the **Education and Communication Award** for tirelessly communicating the needs of Canada's Gen IV nuclear program, facilitating related research and education, and successfully promoting this program within Government. As lead for NRCan, Mr. Brady founded and organized the Canadian Gen IV university program and Canada's leading role in SCWR technology. Perseverance and vision was required to set up this program – the first in decades that spanned Canada, as well as major disciplines of nuclear engineering and science. The program has produced many Highly

Top row (left to right): Marc Kwee, Amjad Farah, Laurence Leung, Ab Tahir, Wie Liauw, Ronald Graham, Gerard Moan, Krish Krishnan, Gordon Hadaller, Daniel Brady, Sriram Suryanarayan, Paul Petherick, Yan Jiang, Zoran Bilanovic. Bottom row (left to right): Rick Hohendorf, Stephen Yu, Adriaan Buijs, Eleodor Nichita, Fred Dermarkar (accepting award on behalf of John Froats), Michael Delage, Liqun Sun.

Qualified Personnel for the nuclear industry, and helped to revitalize infrastructure for university based research.

Dr. Michel Laberge and Mr. Michael Delage were also awarded the **Education and Communication Award** this year. Dr. Michel Laberge is the founder and Chief Scientist at General Fusion Inc., and Mr. Michael Delage is its Vice President. Both Dr. Laberge and Mr. Delage have been actively involved in raising public awareness, through both educational and public outreach, of fusion technology and of the current status of the fusion industry. Through their pro-active media relations, public speaking, public policy, organizing facility tours and crowdsourcing initiatives (i.e., initiatives to engage the public in various aspects of fusion technology development), Dr. Laberge and Mr. Delage have enhanced General Fusion's education and communication program and advocated that nuclear fusion will emerge as one of the clean energy choices.

This year **Dr. Adriaan Buijs**, **Dr. Eleodor Nichita** and **Dr. Krish Krishnan** have been designated as **Fellows of the Canadian Nuclear Society**. **Dr. Adriaan Buijs** has offered his talents and services to the CNS in a multitude of ways for more than 10 years. He served as Chair of the Sheridan Park Branch and later the Golden Horseshoe Branch, served on the CNS Executive first as Secretary, and then as CNS President between 2010 - 2011 and 2013 - 2014, and acted as Technical Program Chair and General Chair for many CNS Conferences. Dr. Buijs is a physicist by training, who worked at AECL Sheridan Park in the early 2000s and later joined McMaster University as a Full Professor in Engineering Physics.

Dr. Eleodor (Dorin) Nichita has been in academia and the nuclear industry for over 18 years. He is an Associate Professor at the University of Ontario Institute of Technology (UOIT) since July 2004, and was previously a Reactor Core Physicist at Atomic Energy of Canada Limited (AECL). Dr. Nichita has made significant service to the CNS, which included his tenure as President in 2009 - 2010, as well as member and chair of many other committees and educational outreach activities. His service has been broad-reaching and important to the industry and academia.

Dr. Krish Krishnan joined the Canadian Nuclear Society in 1985. His extensive service to the CNS for nearly two decades has provided a major contribution to the success of the CNS in achieving its objectives. Dr. Krishnan spent more than 35 years in Research and Development (R&D), engineering, business development, marketing and senior management in the nuclear industry and concurrent university research. For most of his career, Dr. Krishnan was employed at Atomic Energy of Canada Limited (AECL), initially at the Whiteshell Laboratories, and then at Sheridan Park.

The **R.E. Jervis Award** was awarded to **Mr. Amjad**

Farah, a graduate student at the University of Ontario Institute of Technology, is the recipient of the R.E. Jervis Award this year for his research work on the application of Computational Fluid Dynamics (CFD) codes for the purposes of understanding heat transfer in supercritical water for use in the next-generation Supercritical Water-cooled Reactors (SCWR). His work on numerical models has shown high accuracy in predicting experimental trends in supercritical-water flows.

The final presentation was for **CNS President's Award**, which was awarded to **Mr. Duncan Hawthorne**. Mr. Hawthorne has had a profound positive impact upon the Canadian nuclear industry, and is one of its most respected and influential leaders. He has displayed an outstanding ability to articulate a vision, overcome adversity and provide dynamic, innovative and inspirational leadership. Mr. Hawthorne is a tireless advocate of the nuclear industry both at home and abroad. He has served as the Chairman-Elect of the Board of Governors of the World Association of Nuclear Operators, and as the Chairman of the Board of Directors of the Canadian Nuclear Association. While serving in these capacities he has debated the future of nuclear power and appeared as a witness before Canada's Senate Committee.

What a remarkable slate of recipients! Congratulations once again to all the honourees, who represent so well our nuclear community in Canada and internationally. Stay tuned for the Call for Nominations for the 2017 Canadian Nuclear Achievement Awards, which will come out this fall. On behalf of the CNS and CNA Honours and Awards Committee, I encourage you to continue to nominate your meritorious colleagues and join us next year to celebrate their achievements!

L-3 MAPPS to Supply Full Scope CANDU Simulator for Wolsong Unit 1

MONTREAL, April 12, 2016 – L-3 MAPPS announced today that it has secured a contract from Korea Hydro & Nuclear Power Co., Ltd. (KHNP) to supply the full scope operator training simulator for the Wolsong Unit 1 (Wolsong 1) nuclear power plant. The project will start immediately, and the simulator is scheduled to be completed in the first quarter of 2018.

"We are grateful to KHNP for this latest opportunity to demonstrate why our nuclear power plant simulators are second to none," said L-3's Michael Chatlani, vice president of marketing & sales for L-3 MAPPS Power Systems and Simulation. "In addition to our recent simulator projects at Embalse and Cernavodă, the work on Wolsong 1 further aligns L-3 to offer best-in-class simulator solutions for new CANDU* build programs, especially in Argentina, China and Romania."

The Wolsong 1 full scope simulator will use L-3's industry-leading PC/Windows-based graphical simulation tools for the plant models and instructor station. All of the plant systems will be simulated, including the reactor, nuclear steam supply systems, balance of plant systems, electrical systems and I&C systems. The simulator's models will be developed, validated and maintained in L-3's Orchid® simulation environment. The plant computer systems, known as Digital Control Computers (DCCs), will be represented by a fully emulated dual DCC that will be integrated in the full scope simulator. The simulator will be equipped with full replica control room panels driven by L-3's Orchid Input Output software and a new compact input/output system.

The new plant models will also be complemented with severe accident simulation capabilities by including a version of the Modular Accident Analysis Program, known as MAAP4-CANDU**, L-3's first implementation of severe accident simulation for CANDU plants. The simulator will additionally be equipped with new two-dimensional and three-dimensional animated, interactive visualizations of the reactor vessel and containment building to provide trainees further insight into the behavior of the plant during severe accidents.

KHNP, a subsidiary of Korea Electric Power Corporation (KEPCO), provides about 30 percent of South Korea's electricity supply, making it the nation's largest power generation company. It has a total installed capacity of more than 27,000 MW through the operation of 25 nuclear power units, 35 hydropower units, 16 pumped-storage power units and a number of renewable energy facilities. The Wolsong site in Gyeongju, North Gyeongsang Province, houses four 700 MWe class CANDU reactors, Units 1 to 4. The 30-year operating license of Wolsong 1 ended in November 2012. On February 27, 2015, the Nuclear Safety and Security Commission approved a 10-year license extension until November 2022 for the refurbished and uprated Wolsong 1 reactor, and the unit returned to service on June 23, 2015. The full scope operator training simulator for Wolsong Units 2, 3 and 4 was supplied by L-3 MAPPS.

L-3 MAPPS has over 30 years of experience in pioneering technological advances in the marine automation field and over 40 years of experience in delivering high-fidelity power plant simulation to leading utilities worldwide. In addition, the company has more than four decades of expertise in supplying plant computer systems for Canadian heavy water reactors. L-3 MAPPS also provides targeted controls and simulation solutions to the space sector. To learn more about L-3 MAPPS, please visit the company's website at www.L-3com.com/MAPPS.

Headquartered in New York City, L-3 employs approximately 38,000 people worldwide and is a leading provider of a broad range of communication and electronic systems and products used on military and commercial platforms. L-3 is also a prime contractor in aerospace systems. The company reported 2015 sales of $10.5 billion. To learn more about L-3, please visit the company's website at www.L-3com.com.

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Dear Editor:

re: "Infamous Anniversaries: Learning from Severe Accidents"

First, I wish to congratulate you and publisher Colin Hunt for an interesting and informative March 2016 issue of the *CNS Bulletin.*

However, there was one short paragraph in your paper titled: *Infamous Anniversaries: Learning from Severe Accidents* which included a significant error regarding an important safety requirement for Canadian power reactors – the requirement for two independent shutdown systems.

You state that this arose from the 1952 accident at NRX. That is NOT correct.

The many reviews of the NRX accident did lead to the realization that the shutdown system should be independent of the operating system. It also led to several studies of what should be the target for the likelihood of an accident with potential lethal consequences but nothing specific was defined. But it was more than a decade later that the "two-shutdown" concept was developed and established as a requirement.

Some organizational history is required.

The Atomic Energy Control Board (AECB), the forerunner to the current Canadian Nuclear Safety Commission, had been created in 1946, with broad power over all "atomic energy" activities. It was focussed primarily on security and had a professional staff of only one person. The National Research Council (NRC) was responsible for the Chalk River Nuclear Laboratory (CRNL) until Atomic Energy of Canada Limited when it was created in early 1952.

The regulatory requirement for two independent shutdown systems did not evolve until the design phase of the Bruce A station in the late 1960s. It was NOT applied to the prototype NPD reactor, nor the follow-up Douglas Point one, nor the first units of Pickering A.

In the late 1950s AECB had created a senior level advisory committee, the Reactor Safety Advisory Committee (RSAC). George Laurence, a senior manager at CRNL, was appointed Chair. By 1960 he realized that the committee needed full-time support and the AECB began building a technical staff.

I was the first to be engaged and soon became secretary of the RSAC. Additional advisory committees were created and further technical staff engaged.

When Laurence was appointed the first full-time President of in the AECB in late 1961 he chose to continue chairing the RSAC. That created a formality problem leading to my writing the formal reports from the RSAC to the AECB, as executive secretary, and the formal letters from the RSAC to the applicants.

In the mid 1960s the Ontario Hydro designers of Bruce A proposed the relatively small; box-like, containment that is characteristic of the Bruce and Darlington plants.

The RSAC requested that the designers show that this proposed containment could contain the release from a dual accident of the operating system and failure of the shutdown system (that had become the basic safety requirement following the lessons from the NRX accident).

The designers at Ontario Hydro (as the utility was then called) and their partners at AECL admitted they could not.

Then followed a series of correspondence between Bill Morison, then chief engineer at Ontario Hydro and myself as executive secretary of the RSAC. Morison first offered to add some further "trips" (shutdown initiators). This approach was refused by the RSAC.

After several months of several approaches which were rejected by the RSAC he finally agreed to add a separate shutdown system, equivalent to the first. The adequacy of the proposed new system was the focus of several further meetings of the RSAC until the current concept for a second shutdown system was accepted.

I still have copies of the extensive correspondence between Morison and myself.

As an added aspect of this history, at about the same time there developed in the USA a similar argument that was given the name Anticipated Transient Without Scram (ATWS) which went on for almost a decade without a clear resolution.

Fred Boyd

Dear Editor:

re: "The Public May Fear Nuclear Based on Our Own Words"

Kudos to Martyn Wash for reviving a topic that has long been ignored by the nuclear industry, reported in the CNS Bulletin, March 2016.

Accurate and comprehensible terminology is vital to the messages that the nuclear industry is or should be conveying to the public. Agreeing on terminology that will satisfy all stakeholders is, however, easier said than done.

During the early 1980s at AECL, E. Rosinger and I attempted (through publications and presentations) to make "used fuel" the default term for fuel removed from a reactor after its designated lifetime. Unfortunately, it was largely in vain, since the term "spent fuel" dominated the literature, owing to its favoured use by the U.S. and other countries. The term "irradiated fuel" was also used in Canada but, in my opinion, it added to the confusion rather than detracted from it. The term "nuclear fuel waste" adds to the complexity since that is exactly what used fuel is until a decision on reprocessing is made. This example demonstrates the difficulties in even agreeing on a term for what is a relatively simple and topical part of the nuclear fuel cycle.

Getting the industry to agree to terms that are accurate, comprehensible and lacking the "spin" often associated with lobbyists will not be easy. Thus, for example, the terms "used fuel", "recycled" or "recyclable" are accurate, comprehensible and give the right message. On the other hand, "future energy store" and "waste sequestration" (a term not well understood despite its frequent use) sound a little like something out of the spin doctor's office. Individuals will, no doubt, have many more opinions and getting those opinions to coalesce will be a daunting task.

Personal opinions aside, the theme of Wash's article cannot be denied. The CNA (and/or the CNS) should follow up on the initiative and, after performing the necessary studies combined with industry and public feedback, suggest appropriate terms for use in Canada. The terms would not necessarily replace existing technical terms but, rather, supplement them depending on the audience. Estimates of the potential energy available in used fuel, expressed in "people speak" (e.g. barrels of oil equivalent, net CO_2 avoided) would also be useful if the industry is to promote what is now nuclear fuel waste as a significant future source of energy.

Robert Dixon M.Sc., Ph.D., FCIC
Science Communications Consultant
Former Chair of the CNS Ottawa Branch

Canadian elected VP / President-elect of Pacific Nuclear Council

Kamal Verma, Vice-President, CANDU 6 Fleet Program at SNC Lavalin Nuclear, and a long-time member of the Canadian Nuclear Society, has been elected Vice-President / President Elect of the Pacific Nuclear Council (PNC).

The result of the election, held in the spring of 2016, was formally declared at a meeting of the PNC held in Beigin, China, April 5, 2016 and broadcast more widely by the current PNC President, Mimi Limbach of the American Nuclear Society (ANS), during her address to the Pacific Basin Nuclear Conference (PBNC) held at the same venue that week.

Following the PNC constitution, the actual transfer of officers will take place in the fall, at the next meeting of the PNC being held this November during the ANS winter Conference

PNC is an organization of 15 nuclear societies and associations in countries surrounding the Pacific Ocean. Its focus is promoting cooperation between these organizations. A major role is authorizing the PBNC biannual series of international conferences. Canada, led by the CNS, held a very successful PBNC in Vancouver in August 2014.

Kamal, formerly of India, has a long experience with the Canadian nuclear program, starting back in 1975 when he joined Canatom. In 1981 he began a 20-year period with NB Power where he held a series of positions of increasing responsibility at the Point Lepreau NGS.

In 2001 he joined AECL's commissioning team on the Qinshan project in China until 2003, when he joined the commissioning team for the Cernavoda 2 unit in Romania. In 2008 he returned to Canada but remained connected with the Cernavoda project as Senior Technical Advisor. In 2015 he was appointed to his present position as VP, CANDU Fleet Program, at SNC Lavalin Nuclear.

His role at PNC will keep him in touch with senior nuclear officials in the countries with member societies and associations.

The Toronto Radiation Scare of 1961

by M.J. BROWN, P.Eng., FCNS

The Prenco warehouse.

A few years back I discovered bound copies of "*Canadian Nuclear Technology*" in the Chalk River Laboratories library. This magazine, published by Maclean-Hunter from 1961 to 1967, was a treasure trove of Canadian nuclear news. One story which caught my eye was "*Three-day radiation scare grips Downtown Toronto,*" published in the Summer 1961 edition.

A number of children had broken into a Toronto warehouse, owned by Prenco Progress and Engineering Corporation Ltd, ostensibly to recapture an escaped hamster. Once inside, the children pried open a crate containing vials of luminous paints, smashed open some vials, and sprinkled the contents on their clothes. You guessed it; the paint was radium-based, used for painting aircraft instrument dials. The resulting contamination required a clean-up of several locations in the neighbourhood. Most worrisome was the possibility that the children may have inhaled or ingested some paint – for example, traces were found on the peel of an orange eaten by a boy. Thankfully, tests at Toronto's Hospital for Sick Children, the Toronto Department of Health laboratory and the University of Toronto physics laboratory showed that the children had received only small doses of radiation, "*about the same as from a (radium dial) wrist watch.*" The article ended by describing how this industrial incident had been linked to nuclear weapons: "*the scare involved in this incident has been reflected in the attitude of Torontonians to the possibility of Canada adopting nuclear arms. A petition on the subject is being circulated for future presentation to the Federal government.*" Some things haven't changed!

I was intrigued, but the article collected "e-dust" in my computer for several years, occasionally being shared with colleagues interested in nuclear history. However, a recent report by the Low-Level Radioactive Waste Management Office (LLRWMO) described a few remediation and clean-up projects in the Greater Toronto Area, prompting me to enquire if the LLRWMO had any further information on the 1961 radium scare. They did not, and suggested I contact the Canadian Nuclear Safety Commission (CNSC), which had succeeded the Atomic Energy Control Board (AECB) in the year 2000.

The CNSC could not readily find a record of the incident in their archives, but pointed out that Prenco (http://www.prenco.com) still existed and suggested I contact them. I did so, expecting little in return – the incident happened 55 years ago, and here was I digging up a story that must have been both embarrassing and expensive. To my pleasant surprise, Josef Viezner of Prenco replied very positively, thanking me for reaching out and stating he "*would be very happy to share a rather – how should we say – colourful chapter of Prenco's long history.*" Josef willingly agreed to me writing this article, fleshing out the story from a large file of documents his great grandfather Josef Chmel had compiled. Fantastic!

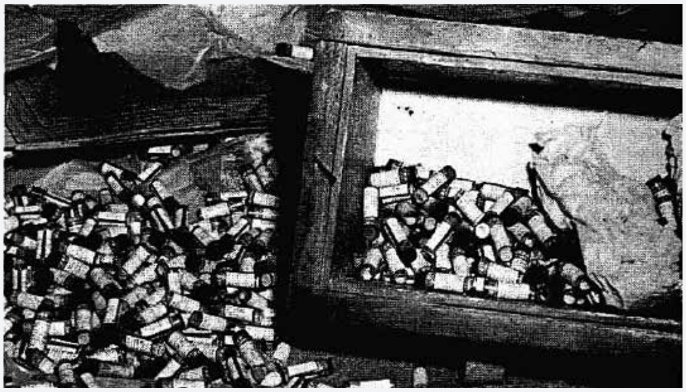
Chmel had immigrated to Canada from Czechoslovakia before World War II, bringing with him experience as an industrialist. He founded Prenco Progress & Engineering Corporation Ltd in 1939, operating out of an old machine shop at 72 Stafford Street in downtown Toronto. During the war Prenco manufactured gun trigger mechanisms, hydraulic flexible hose, fittings, and self-sealing couplings. In the 1950s they made parts for other aircraft, including the Avro Arrow. Today they are located in Pickering, specializing in automobile ignition wire sets.

One of Prenco's wartime jobs was to paint aircraft instrument dials with glow-in-the-dark paint incorporating radium-226 (1600 year half life). According to Wikipedia, radioluminescent paint was invented in 1908. Unfortunately, a number of "Radium Girls" suffered very serious health effects (and some died as a consequence) from their work painting aircraft dials during World War I and the early 1920s, when they were encouraged to point their brushes with their lips and tongue. That's another history lesson.

Back to Toronto, 1961. On Monday June 5th, a group of kids broke into the Prenco warehouse in a back lane behind 141 Strachan Ave, not far from Prenco's office on Stafford St. According to the Toronto Daily Star of June 7th, "*A tiny, white hamster named Pinky was responsible for the incident, police revealed. Several juvenile boys later unscrewed the padlocked hinge of the garage to retrieve the hamster for* [its owner] *Pat*".

Prenco staff had a somewhat different view of the matter, and kept a record of the June 6th visit by Detective Sergeant Joyce, Criminal Investigation Department of the Metropolitan Toronto Police. Det. Joyce "*remarked that the children in this neighbourhood are up to all kinds of malicious acts, climbing over roofs, and breaking into houses, etc. It was explained to Det. Sgt. Joyce that our storage shed had been securely locked with a padlock and the doors nailed up. It must have been somehow forced open.*"

According to the Prenco record, the box was made with 3/4 inch plywood, entirely lead-lined and held together with three-inch nails. Despite this, it had been forced open, and still held "*750 odd vials, and another 20 odd were found in the shed.*" The picture in Canadian Nuclear Technology shows many vials scattered outside the box.



The broken plywood box and vials of radioluminescent paint, from Canadian Nuclear Technology, Summer 1961.

According to the June 6th Toronto Telegram ("Radium Stolen, Children In Peril"), a woman found her son playing with the vials, with labels "*identifying them as poisonous luminous radium.*" She called police, and "*Fire Department Platoon Chief Charles O'Hara tested the vials with a Geiger counter and found them radioactive. ... The police found 500 vials strewn around a parking lot near the shed. Only a few are believed still missing.*"

The next morning, the news hit the front page of the Toronto Daily Star ("14 Children Given Tests"). A total of about three dozen children "*were rushed from two schools to the Hospital for Sick Children for radioactivi-*

ty tests. Those who got a reaction from Geiger counters were scrubbed thoroughly and sent home in hospital nightshirts. [The affected] *children underwent tests at the University of Toronto's Physics Department.*"

One concerned father, employed at a local service station, took several vials from his 10-year-old son, and burned them in the station incinerator. One wonders if he was simply trying to keep his son out of trouble with the police - after all, the Star said "*no charges have yet been laid, but several boys are still being questioned*". The Star also listed the names and ages of fifteen children involved, "*all of Strachan Avenue*"; they ranged from three to fourteen years old. The following day, June 7th, the Toronto Daily Star headline appeared in 1-inch letters ("HOUSE-TO-HOUSE CHECK FOR MORE RADIUM VICTIMS"), accompanied by a photo of one young boy (who was named) being examined with a Geiger counter. Another photo shows three anxious girls in a school being "*given a radiation check by an official from the Ontario department of Health.*" This level of detail about minors would not be permitted today.

The parents were undoubtedly frightened by their children getting contaminated, and had to await the test results ("*the 14 … will not know for at least three days whether they have been seriously injured*"). Were they also ashamed, that their children had entered private property, caused a mess, were now publicly named and potentially faced police charges?

The AECB was soon involved, having been informed by the Ontario Department of Health. G.M. Jarvis, Legal Advisor and Secretary to the AECB, wrote to Prenco on June 7th that the AECB had "*never authorized* [Prenco] *to acquire and use such radioactive material*". The letter requested details of the quantity of luminous compound; radium content; vendor address; date of the acquisition; purchase permits; package labelling; and method of storage.

A second letter from Jarvis, dated June 14th, reiterated the request for information since no reply had been received. He didn't mince words: "*You are hereby required, pursuant to Section 300 of the Atomic Energy Control Regulations, to furnish to the Board in writing, by noon on the 20th day of June, 1961, all information in your possession or power.*" During a June 19th phone call with Jarvis, Prenco staff explained they had sent a reply on Friday June 16th.

Prenco had a single record of purchasing radium paint, showing a final payment of $46.57 to Radium Luminous Industries Ltd on May 15 1946. Given that the Canadian Atomic Energy Control Act (establishing the AECB) was proclaimed on October 12 1946, it is no wonder that the radium paint was not registered with the Board. The vials were labelled "United Radium Corporation" of New York, and presumably Radium Luminous Industries was a vendor. An interesting side note is that Radium Luminous Industries operated in Scarborough, Ontario. According to Wikipedia, the company "*extracted radium from scrap metal to be used in experiments for accelerated plant growth.*" The soil became contaminated, but the Ontario government purchased the land in the 1970s for a housing project. The contamination was discovered on McClure Crescent in 1980 and McLevin Avenue in 1990; the provincial government bought back some properties and removed some 16,000 cubic metres to a monitored site on Passmore Avenue. Details on the Malvern Remedial Project are available from the LLRWMO.

Dr. L.B. Leppard, a physicist with the Ontario Department of Health, and J.F. Greenlaw, a District Inspector of the Ontario Department of Labour, visited Prenco on June 7th. Based on their inspection G.F. Robbins, Assistant Chief Inspector of the Department of Labour, wrote to Prenco General Manager A.E. Winter on June 8th: "*You are required to decontaminate and remove all radium contamination. … This direction shall be completed immediately* [by employing] *a contractor who is qualified and experienced in this work and approved by the Ontario Department of Labour and the Ontario Department of Health*."

Two contractors were recommended – X-Ray & Radium Industries of Don Mills, and Atomic Energy Co. of Canada Ltd. [sic] of Ottawa. Prenco phoned X-Ray and Radium Industries, requesting a visit on the morning of June 8th. However, Mr. Sobel of Prenco "*advised that we should try to obtain at least one more quotation, … in case one firm qualified would take advantage of our situation*."

R. Billings, of X-Ray & Radium Ltd, provided a quote on June 9th, stating his company would remove:

1) All radium contamination from Prenco storage shed and parking lot at 141 Strachan Avenue
2) *All radium luminous compound and contamination now at Prenco, 72 Stafford St.*
3) *Incinerator and ashes from service station at 1800 St. Clair Ave. West*
4) *All contaminated articles from #3 police station*
5) *Contaminated clothing* [stored in] *the office of Dr. L.B. Leppard*
6) *Contaminated clothing and other articles from certain private homes*
7) *Contaminated living room chair from verandah at 141 Strachan Ave.*

The quoted cost? "*A $500 fixed fee, plus a charge of $10 per man hour of labour involved in carrying out all of the above work, plus time involved in preparing for shipment to suitable disposal area. Shipping charges ex Toronto, disposal charges and equipment and tools consumed in the operation will be billed at cost.*"

According to the Bank of Canada inflation calculator, $10 in 1961 is equivalent to $81 in 2015.

Evidently Prenco were concerned about the open-endedness of the above proposal, and sought additional quotes. On June 15th, Winter asked if the AECB might suggest other qualified contractors. Jarvis of the AECB phoned on June 19th, advising that he had "*explored getting another firm, …* [but] *none can be located outside of Atomic Energy Co.* [sic] *Ottawa. If you take this firm they would have to charge transportation for their men from and return to Ottawa, also transportation to Chalk River, and it could be more costly than to take X-Ray Industries*". Jarvis added "*that it is now strictly up to* [Prenco] *to get on with it* [and] *to work closely with Dr. Leppard*." In addition, the City of Toronto Department of Public Works had placed six barricades, "*at the request of the Ontario Department of Health and the Metropolitan Police Department* [at] *30 cents per day for each barricade used*". No wonder Prenco told the AECB they were "*anxious to get it settled*".

Meanwhile J.K. Chmel, owner of Prenco, received word of the incident while at a conference in Vienna. He sent a reply to his staff on June 18, and didn't mince words: "*The whole affair is a case of youth pilfering, having broken the locked and nailed door of one of our storage rooms … This behaviour of youth in our neighbourhood is unfortunately known to us. Our window panes are systematically smashed, the fence torn down and other mischief done. I cannot understand the whole excitement and panic. The attitude of the press is irresponsible.*"

Chmel continued in a defensive and defiant fashion "*The fact that the vial (one vial) contained one gram of the relatively harmless powder speaks for itself. Do you know what one gram of real radium would cost? … What is radioactivity anyway? There are radioactive spas, radioactive herbs and roots, all very beneficial to the human being. Briefly: children and youth have nothing to do on other people's property. If they broke in then they belong before a Judge. Prenco cannot and will not take any responsibility. … If authorities intend to do any prophilaxion then they have to reimburse Prenco for all expenses. What a panic for the behaviour of 'wild' kids. … Please report re steps of our lawyer for safeguarding Prenco's interests.*"

N. Delahunty, Commercial Products Division of AECL, Ottawa, gave a quotation for the decontamination work on June 27th. Their hourly rate was $7 per person, plus a $75 charge for hotel for an estimated five days. The total quote from AECL was $1075, plus approximately $25 to transport the barrels of waste to Ottawa, whereas X-Ray & Radium Ltd was expected to charge about $1700. Thus AECL was contracted for the work, beginning Wednesday June 28th, 23 days after the children broke into the warehouse. A Prenco bill of lading shows that "*15 drums containing radium-contaminated items*" were shipped on July 4th to AECL's Commercial Products Division at Punney's [i.e., Tunney's] Pasture in Ottawa.

The final scene played out under the eye of the law. Detective Joyce wrote to Prenco on July 5th, identifying the alleged culprit as a nine-year old boy attempting to find an escaped hamster. In response, Prenco's lawyer, Mr. Olch, suggested that Prenco write a letter requesting that some of their expenses be borne by the boy's parents: "*in such cases, usually the parents will co-operate if they have any money, and at least we could get something towards our costs.*"

Prenco's General Manager Winter wrote to the boy's parents on September 20th and, at a meeting the following day, told the father J. Baboni, "*that perhaps you are responsible for the entrance of your son into our sheds*". Baboni "*replied that after checking the health situation of his son* [Prenco] *will hear more from him.*" He also stated he had closed and locked the Prenco warehouse doors himself on many occasions, and that "*if a 9 year old boy could open the door there must be something else wrong*". Finally, Baboni said that Prenco "*had no business storing the stuff*". From the lack of further records, I surmise that Prenco received no compensation.

And what of the children contaminated in the incident? The Toronto Daily Star reported ("Radium Children Safe Now", June 14) that "*The 14 West Toronto children who were exposed to radio-active luminous powder are in no danger, Dr. R.B. Sutherland of the Industrial Hygiene Division, Provincial Department of Health, said last night. Results of tests conducted on the children and three adults also exposed to the radium powder show 'nothing to be alarmed about'.*"

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Synthetic Fuel Production via Carbon Neutral Cycles with High Temperature Nuclear Reactors as a Power Source

by E. KONAREK[1], B.COULAS[1], and J.SARVINIS[1]

Abstract

This paper analyzes a number of carbon neutral cycles, which could be used to produce synthetic hydrocarbon fuels. Synthetic hydrocarbons are produced via the synthesis of Carbon Monoxide and Hydrogen. The cycles considered will either utilize Gasification processes, or carbon capture as a source of feed material. In addition the cycles will be coupled to a small modular Nuclear Reactor (SMR) as a power and heat source. The goal of this analysis is to reduce or eliminate the need to transport diesel and other fossil fuels to remote regions and to provide a carbon neutral, locally produced hydrocarbon fuel for remote communities. The technical advantages as well as the economic case are discussed for each of the cycles presented.

1. Introduction

The production of synthetic fuels via carbon neutral cycles could prove to be an important technology to control the current trend of increasing atmospheric carbon dioxide levels. This paper analyzes potential pathways to a carbon neutral cycle and discusses how a small nuclear power plant could prove useful in these cycles. Various carbon neutral cycles that utilize a small modular Reactor (SMR) are analyzed and compared. In this study Generation IV High Temperature Gas Reactors (HTGR) will be considered as the nuclear power source. In comparison to classic Gen III reactor designs these reactors output significantly higher temperature gas from the reactor core. Higher temperature gases are useful for hydrogen production and other process uses.

2. A Biomass Carbon Neutral Cycle

Biomass Gasification cycles are a leading method of producing synthetic fuels with a carbon neutral, or nearly carbon neutral, fuel production cycle. In simple terms gasification of biomass occurs when the feed material (biomass) is reacted with a limited amount of oxygen. This reaction results in the incomplete combustion of the hydrocarbons in the feed and the production of hydrogen and carbon monoxide. The gasification reaction can be defined as follows [1]:

$$C_n H_m + \frac{n}{2} O_2 \rightarrow nCO + \frac{m}{2} H_2 \tag{1}$$

Depending on the type of process and feed the ratio of CO to H_2 produced by the gasification of biomass will vary. For the purposes of this study it is assumed, in reference to existing biomass gasification processes, that the product will have an H_2: CO ratio of 0.5. The required ratio of the two gasses will be largely dependent on the desired product fuel, as well as the type of synthesis reactor used. For the purpose of this study it is assumed that the ratio of hydrogen to carbon monoxide required for fuel synthesis will be 2:1 [2]. In order to adapt the product from a CO rich stream to a hydrogen rich stream one of two methods is commonly used.

Water Gas Shift: The water gas shift converts carbon monoxide and water to hydrogen and carbon dioxide, via the following relationship [1]:

$$CO + H_2O \rightarrow H_2 + CO_2 \tag{2}$$

Steam Methane Reforming: The reforming of natural gas with steam produces carbon monoxide and hydrogen via the following reaction [1]:

$$CH_4 + H_2O \rightarrow 3H_2 + CO \tag{3}$$

These two processes while effective at producing additional hydrogen, also introduce waste carbon into the system. This is an issue as the cycle can no longer be considered carbon neutral.

To rectify this issue a proposal is made for a nuclear hydrogen production source that could be used to produce the hydrogen emissions free, via electrolysis. This plant would involve a nuclear small modular reactor and electrolysis equipment to produce hydrogen. Due to the use of electrolysis it is anticipated that the cost of hydrogen production will be high and as such the economics of this scenario will be hampered. This design will be considered in line with carbon and hydrogen electrolysis/capture cycles introduced in following sections.

3. Carbon Dioxide Capture and Electrolysis Hybrid Cycles

Several cycles that combine carbon dioxide capture and Hydrogen produced by electrolysis have been pro-

1 Hatch Ltd., Mississauga, Ontario, Canada

posed in research. Some of these technologies such as the Audi E-diesel are reported to be near commercialization [3]. The common factor between these cycles is the usage of captured carbon dioxide as a feed material, and the combination of this feed material with hydrogen to form synthetic fuels.

3.1 Challenges to Carbon Dioxide Capture

The capture of CO_2 is the first major technical challenge to any hybrid electrolysis cycle. CO_2 capture from plant output, particularly natural gas, is in practice at various locations around the world. CO_2 has rarely been captured from the air, and never on a large scale [4]. Technologies such as that designed by Canadian company Carbon Engineering are moving towards a commercialized carbon capture plant [5]. The invention of a large scale carbon capture, from air, plant coupled to a small modular nuclear hydrogen producer, would remove the geographical limits on a synfuel plant and allow production to take place anywhere nearby the fuel demand.

3.2 Electrolysis

Electrolysis is a process that utilizes electrical potential to separate a molecule. 3 Types of electrolysis are relevant to the cycles. Each is discussed below:

1) Water is electrolyzed into hydrogen and Oxygen. This is a well proven technology and is the lowest cost however it requires large amounts of input electricity.
2) Steam is electrolyzed into hydrogen and oxygen. This technology is nearing commercialization and while it will be more expensive than conventional electrolysis, the electrical requirement will be significantly reduced as thermal energy assists in the splitting of the water molecule.
3) Steam and Carbon Dioxide are directly split into Hydrogen, Carbon Monoxide and Oxygen. This method of production is the furthest from commercialization and would be the most expensive to commercialize. It will present savings in the quantity of hydrogen that must be produced via electrolysis. In both options 1 and 2 above the reverse of the water gas shift reaction (introduced in section 2) is used to produce carbon monoxide, requiring an excess of hydrogen.

3.3 Synthetic Diesel Production

Synthetic Diesel can be produced from a Syngas product with the correct ratio of H_2 to CO in the presence of an appropriate catalyst. Fischer-Tropsch reactor vessels are used to facilitate this fuel synthesis [1]. The produced diesel may require some additional processing for compliance with environmental regulations, but for the most part could be used as a fuel in any diesel operated internal combustion engine.

The reaction taking place in a Fisher-Tropsch reactor is characterized below [1]:

$$(2n+1)H_2 + nCO \rightarrow C_nH_{(2n+2)} + nH_2O \tag{4}$$

In the above n is typically 10-20 and the formation of methane (n=1) is unwanted.

3.4 Synthetic Methane Production

The Syngas mixture of Carbon Monoxide and Hydrogen gas can also be synthesised into methane. Methane being the largest component of natural gas can be used to serve domestic or industrial natural gas needs, or as a fuel for natural gas vehicles. The methane formation reaction is called the Sabatier reaction, and was developed over 100 years ago. The reaction takes two forms, hydrogen reacting with carbon dioxide or hydrogen reacting with carbon monoxide. The equations for these reactions are presented below. It can be seen from the below that the advantage of utilizing carbon monoxide over carbon dioxide is the decreased hydrogen requirement [6]:

$$3H_2 + CO \rightarrow CH_4 + H_2O \tag{5}$$

$$4H_2 + CO_2 \rightarrow CH_4 + 2H_2O \tag{6}$$

4. Use of a Small Modular Reactor

This paper suggests the use of a small modular reactor for the following reasons:

- All Electricity is provided to the process free of CO_2 emissions
- Hydrogen as well as carbon monoxide will be produced at a high purity; the syngas will require less treatment than conventional processes.
- Equipment required for the process is minimized.
- The High Temperature Gas reactor produces high temperature steam. The steam can be used to greatly improve the efficiency of electrolysis.
- Small scale installations can be completed at a lower capital cost allowing the production of fuels in a shorter timeframe.
- Nuclear plants require infrequent refuelling and have high operability factors. This helps to enable the business case for the use of these systems in remote areas, where grid connections are not available.
- Fuels can be produced locally in hard to access locations. Reducing the difficulty of transportation and the associated cost.

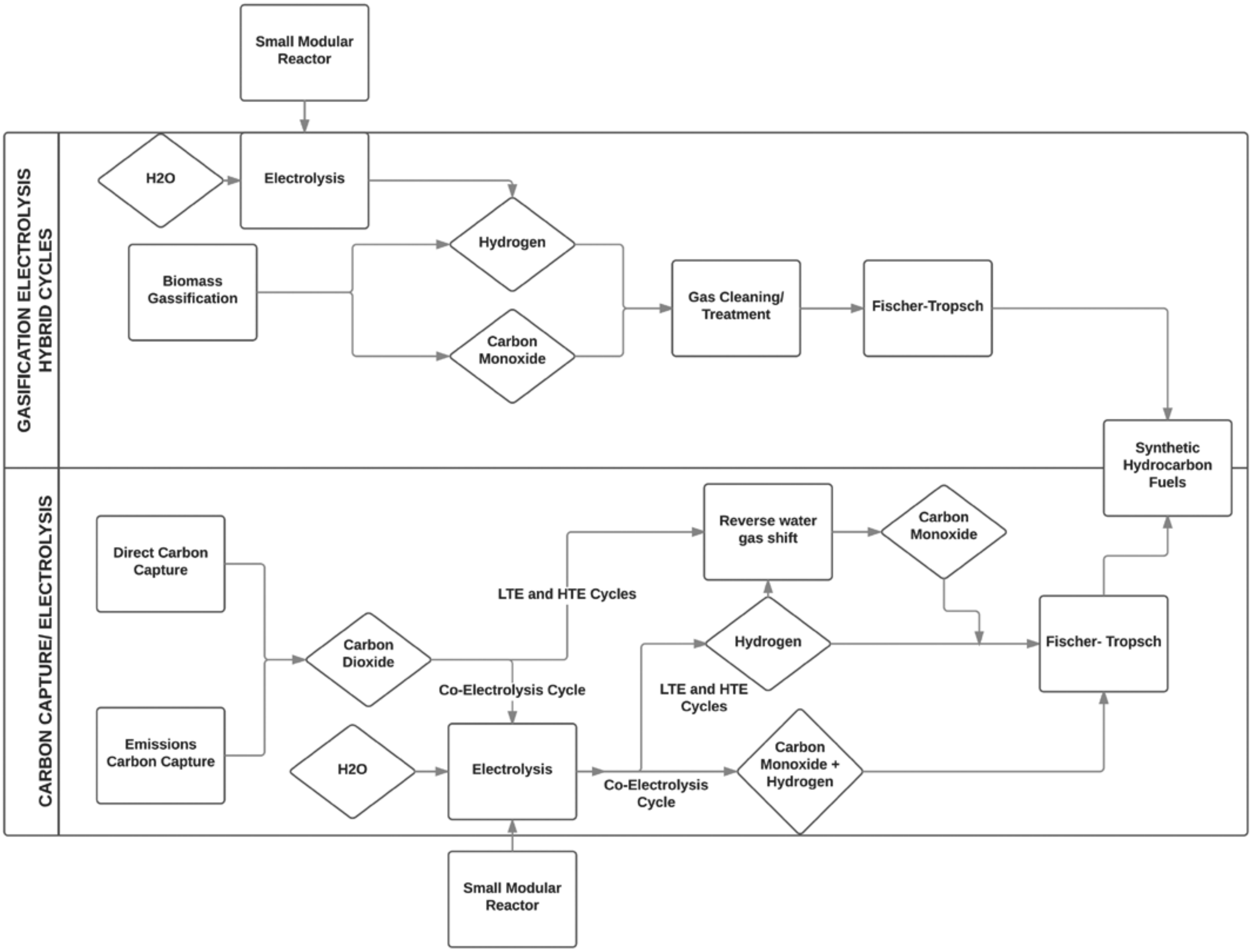

Figure 1: Flow Chart for Analyzed Cycles

5. Comparison of Proposed Cycles

In the sections that follow the product requirements and economics of each of the cycles is considered. The carbon capture / hydrogen electrolysis cycles are assessed in section 5.1, and the proposed hybrid gasification cycle is assessed in section 5.2. Figure 1 above illustrates the different cycles leading to synthetic hydrocarbon fuels, as an example.

5.1 Carbon Capture / Hydrogen Electrolysis Cycles

5.1.1 Reaction Reagent Requirements

The common factor between all of the technologies is the usage of hydrogen and carbon monoxide as reagents to produce the output fuel. The quantity of hydrogen and Carbon Dioxide required in each scenario is assessed below using mass balance. An output of 1kg of the subject fuel is considered.

5.1.1.1 Sabatier Reaction Mass Balance

In order to produce methane the Sabatier reaction is used. As discussed above the reaction takes two forms. A mass balance is completed for each, to determine the required mass of reagent gases required to produce 1kg of methane. The quantities of each species required are detailed in Table 1.

5.1.1.2 Fischer-Tropsch Reaction Mass Balance

In order to produce hydrocarbon fuels the Fischer-Tropsch process is used. To assess the effect the n value has on the reagent masses required scenarios for n=12 and n=18 will be analyzed. Diesel Fuel would correspond to a value of n=10-15. As discussed above 1kg of the synthetic fuel is the desired product. The quantities of each species required are detailed in Table 2.

5.1.1.3 Reverse Water Gas Shift Mass Balance

The reverse of the water gas shift reaction can be used to convert captured CO_2 to CO, which can then

Table 1: Mass Balance for Sabatier Reaction

$3H_2 + CO \quad CH_4 + H_2O$			
Variable	Methane	Carbon Monoxide	Hydrogen
Mass	1 kg = 1000g	1746.3 g = 1.75kg	377.8 g = 0.38 kg
Molar Mass	16.04 g/mol	28.01 g/mol	2.02 g/mol
Moles	62.34	62.34	187.03
$4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$			
Variable	Methane	Carbon Dioxide	Hydrogen
Mass	1 kg = 1000g	2743.6g = 2.74kg	503.7 g = 0.5 kg
Molar Mass	16.04 g/mol	44.01 g/mol	2.02 g/mol
Moles	62.34	62.34	249.36

Table 2: Mass Balance for Fischer-Tropsch Reaction

N=12	$25H_2 + 12CO \rightarrow C_{12}H_{26} + 12H_2O$		
Variable	Methane	Carbon Monoxide	Hydrogen
Mass	1 kg = 1000g	1973.02g = 1.97 kg	296.4 g = 0.3 kg
Molecular Weight	170.335 g/mol	28.01 g/mol	2.02 g/mol
Moles	5.87	70.44	146.75
N=18	$37H_2 + 18CO \rightarrow C_{18}H_{38} + 18H_2O$		
Variable		Carbon Monoxide	Hydrogen
Mass	1 kg = 1000g	1981.02g = 1.98 kg	293.6 g = 0.29 kg
Molecular Weight	254.49 g/mol	28.01 g/mol	2.02 g/mol
Moles	3.93	70.73	145.4

Table 3: Mass Balance for Reverse Water Gas Shift Reaction

$H_2 + CO_2 \rightarrow CO + H_2O$			
Variable	Carbon Monoxide	Carbon Dioxide	Hydrogen
Mass	1.98 kg = 1981g	3111.5 = 3.11 kg	142.8 g = 0.14 kg
Molecular Weight	28.01 g/mol	44.01 g/mol	2.02 g/mol
Moles	70.7	70.7	70.7

be synthesised with hydrogen to produced synthetic hydrocarbon fuels by the Fischer-Tropsch process discussed above. In this case the required carbon monoxide of 1.98 kg calculated above is used as the value for required output. The quantities of each species required are detailed in Table 3.

5.1.2 Levelized Cost of Components

In order to accurately compare all costs, levelized cost of production in kg will be used for each sub component of the systems. The components of the electrolysis plant are considered below in Table 4. It is assumed that the levelized cost of electricity provided to each system is provided at a constant value of 16 ¢/kWh [7]. The cost of other equipment in the system was estimated as discussed in the table.

Table 4: Cost of Electrolysis Components

Equipment	Levelized Cost/kg of product	Source
Standard Electrolysis Unit	\$0.36/kg	produced using capital cost, operating cost, and production metrics from the paper by Saur et al, and assuming a 40 year lifetime, a 7 year replacement period, and an a 8% discount rate [8]
High temperature Steam Electrolysis Unit	\$0.43/kg	Estimated 20% increase in cost above standard electrolysis
Co-Electrolysis Unit	\$0.54/kg	Estimated 50% increase in cost above standard electrolysis (additional material handling costs beyond high temperature electrolysis)
CO_2 Capture Unit	Direct = 0.66USD/kg Emission capture = 0.088USD/kg	Values obtained from [4] Table 2.5

The Electrolysis units for Low Temperature and the High Temperature units are assumed to have the efficiencies presented in Table 5.

Table 5: Effective efficiency of Various electrolysis mechanisms

Equipment	Efficiency (kWh/kg)	Source
Standard Electrolysis Unit	50	[8]
High temperature Units Electrical hydrogen	35	[9]
High temperature Units Thermal hydrogen	8	[9]
High temperature Units Electrical Carbon Monoxide	6	Estimated Value based on a comparison of the Gibbs free energies of Hydrogen splitting reaction and of the CO_2 to CO reaction.
High temperature Units Thermal Carbon Dioxide	2	Conservative Estimated value based on the percentage relationship between electrical and thermal for hydrogen.

5.1.3 Cost Comparison of Electrolysis Cycles

The study used to reference the cost for a standard electrolysis unit assumed a unit throughput of 50,000 kg/day; this translates to an electric requirement of 104 MW [8]. This will be larger than the reactor required in this application however with a larger nuclear reactor the levelized electricity cost would decrease while the cost of the electrolysis device scales fairly linearly, so the present study will provide a conservative result.

The levelized cost of electricity provided to the electrolysis unit is added to the levelized cost of the electrolysis unit to calculate the levelized cost of the assembly/ kg of hydrogen produced.

In order to estimate the cost of different methods of carbon capture the estimate that is provided in the direct air capture manual is modified with the actual cost of electricity which instead of being \$71/MWh will be estimated as \$160/MWh for the higher levelized cost of electricity for an SMR. This changed the total cost from \$80/ton CO_2 for off gas capture and \$610 for direct capture to \$110/CO_2 ton and \$650/CO_2 ton respectively.

Table 6: Conditions for Methane Production Scenarios

Variable	Low Temp Electrolysis	High Temp Electrolysis	Co-Electrolysis Cell
Levelized Cost of Electricity	16¢/kWh	16¢/kWh	16¢/kWh
Effective Levelized cost of heat		9¢/kWh	9¢/kWh
Electrolysis Efficiency hydrogen (elec)	50 kWh/kg	35 kWh/kg	35 kWh/kg
Electrolysis Efficiency hydrogen (heat)		8 kWh/kg	8 kWh/kg
Electrolysis Efficiency Carbon Dioxide (elec)			6 kWh/kg
Electrolysis Efficiency Carbon Dioxide (heat)			2 kWh/ kg
Electrolysis Unit Cost	\$0.36/ kg	\$0.43/ kg	\$0.54/ kg
Direct Air Capture Cost	\$0.65/ kg	\$0.65/ kg	\$0.65/ kg
Emissions Capture Cost	\$0.11/ kg	\$0.11/ kg	\$0.11/ kg
Hydrogen Gas Required	0.5 kg	0.5 kg	0.38 kg
CO_2 Required	2.74 kg	2.74 kg	2.74 kg

5.1.3.1 Methane Production

The conditions for this scenario are provided in Table 6.

The costs of Hydrogen production is calculated by summing each of the separate \$/Kg costs. The results for each calculation are presented in Table 7

Table 7: Cost for all Methane Scenarios

CO_2 Capture Method	Low Temp Electrolysis	High Temp Electrolysis	Co-Electrolysis Cell
Direct Capture	\$6/kg	\$5.2/kg	\$4.8/kg
Emissions Capture	\$4.5/kg	\$3.7/kg	\$3.3/kg

5.1.3.2 Hydrocarbon Fuel Production

The conditions for this scenario are provided in Table 8 below.

Table 8: Conditions for General Hydrocarbon (n-=12-18) Production Scenarios

Variable	Low Temp Electrolysis	High Temp Electrolysis	Co-Electrolysis Cell
Levelized Cost of Electricity	16¢/kWh	16¢/kWh	16¢/kWh
Effective Levelized cost of heat		9¢/kWh	9¢/kWh
Electrolysis Efficiency hydrogen (elec)	50 kWh/kg	35 kWh/kg	35 kWh/kg
Electrolysis Efficiency hydrogen (heat)		8 kWh/kg	8 kWh/kg
Electrolysis Efficiency Carbon Dioxide (elec)			6 kWh/kg
Electrolysis Efficiency Carbon Dioxide (heat)			2 kWh/kg
Electrolysis Unit Cost	\$0.36/kg	\$0.43/kg	\$0.54/kg
Direct Air Capture Cost	\$0.65/kg	\$0.65/kg	\$0.65/kg
Emissions Capture Cost	\$0.11/kg	\$0.11/kg	\$0.11/kg
Hydrogen Gas Required	0.43 kg	0.43 kg	0.29 kg
CO_2 Required	3.11 kg	3.11 kg	3.11 kg

The costs of Hydrogen production is calculated by summing each of the separate \$/kg costs as was done above in section 5.1.3.1. The results are presented in Table 9 below.

Table 9: Costs for all Hydrocarbon Fuel Scenarios

CO_2 Capture Method	Low Temp Electrolysis	High Temp Electrolysis	Co-Electrolysis Cell
Direct Capture	\$5.6/kg	\$5/kg	\$4.4/kg
Emissions Capture	\$4/kg	\$3.2/kg	\$2.7/kg

Table 10: Cost of Electrolysis Gasification Hybrid

Carbon Monoxide Produced from Gasification	1981.02g
Moles of Carbon Monoxide	(1981.02g)/(28.01 g/mol) = 70.7 mol
Moles of Hydrogen Produced	35.35 mol
Mass of Hydrogen from Gasification	(35.35mol)*(2.02 g/mol)=71.4g
Mass of Hydrogen required from Electrolysis	300-71 =229 g =0.23kg

5.2 Consideration of the Gasification Hydrogen Electrolysis Hybrid Cycle

The cost of a biomass plant is dependent on many factors including: the quality of the feed, the required process, and the desired output fuel. For the purpose of this study the cost analysis work completed by Swanson is used [10]. From the results presented in this paper a reference cost of 4 – 8 $/GGE, will be used to estimate the cost of a standard biomass to synthetic fuel gasification process. The GGE refers to the gasoline gallon equivalent this is a unit used to describe the amount of alternative fuel required to equal the energy content of a gallon of gasoline. The conversion from gallons of diesel to GGE is 1.140 Gal diesel =1 GGE [11].

To estimate the cost of the proposed Gasification Hydrogen Electrolysis Hybrid Cycle the cost of producing supplemental hydrogen via electrolysis is considered. Referring to the mass balance exercise complete in 5.1.1.2 it is assumed that 1.97Kg of carbon monoxide and 0.3 Kg of hydrogen are required to produce 1Kg of synthetic hydrocarbon fuel. The amount of hydrogen produced from gasification is then calculated and the required amount supplied from electrolysis can be estimated. The results are indicated in Table 10.

In an accompanying paper the cost of hydrogen production was estimated to be $8/kg [12]. This equates to an added cost of $1.85/kg of synthetic fuel produced. The total GGE cost including the biomass to fuel and nuclear hydrogen production is estimated to be $9.1-13.1/GGE. It should be noted that the use of electrolysis would also produce oxygen which could be used as a feed for the gasification process; this will reduce the cost required for air separation. Furthermore the use of pure hydrogen produced from electrolysis of H_2O will reduce the requirements for syngas cleaning. The above factors will reduce the effective cost of the synthetic fuel production however it is not anticipated that they will incur a substantial reduction in the cost of the produced fuel per GGE. A larger effect will be incurred by the fact that a water gas shift reactor or a steam reformer is no longer required. As these cost savings are dependent on a number of factors it will be assumed that the cost could reach the lower end of the range at around $9-10/GGE.

5.3 Cost Summary

The costs per kg above are converted to Gasoline gallon equivalent in order to compare to the estimated cost of production via gasification.

A brief analysis of Canadian diesel and natural gas purchase prices was conducted to determine the economic feasibility of synthetic fuels in general. It was found that northern Canada experiences the highest fuel costs with an estimated diesel cost of $1.3/L ($4.92/Gal) or $4.32/GGE[13]. Natural gas costs are significantly lower currently about 20% of the diesel cost for the same energy content [14]. In Table 11 below the lowest cost scenarios are compared.

Current natural gas prices are at such a level that it would not be possible for synthetic natural gas to be produced at a competitive cost. Diesel costs may be an achievable metric in future; especially considering the cost of diesel is expected to rise in coming years. As such all diesel cost scenarios are considered below in Table 12.

Table 11: Lowest Cost Scenarios for Fuel Production

Scenario	Cost	Density	Cost	GGE conversion	GGE cost
Co-electrolysis methane production (Emission Capture)	$3.3/kg	0.656 kg/m3	$2.16/m3	3.587m3=1GGE	$7.8/GGE
Co-electrolysis hydrocarbon fuel Production (Emission Capture)	$2.7/kg	0.8kg/L 3.03 kg/Gal	$8.2/Gal	0.9 G = 1GGE	$7.4/GGE
Gasification Plant producing diesel					$4-8/GGE
Nuclear Gasification plant Hybrid Cost					$9-10/ GGE

Table 12: Diesel Cost Scenarios ($/GGE)

	LTE	HTE	Co-Electrolysis	Gasification	Nuclear Gasification Hybrid
Emission Capture	11	8.7	7.4	4-8	9-10
Direct Capture	15.3	13.7	12	4-8	9-10

6. Discussion of Results

The cost figures above for the electrolysis/capture cycles do not include the cost of the Fischer-Tropsch synthesis reactor, which would be required to synthesise the fuel from the syngas. Referring to the paper by Swanson an estimated levelized cost of a Fisher-Tropsch unit was estimated to be $0.02/Kg [10]. Considering the high level of uncertainty for the cost estimates made in this study this cost will have a negligible effect on the results.

Comparing carbon neutral cycles based on the results of section 5.3 it is noted that the cost of fuel production using capture/ electrolysis processes is lower than the carbon neutral cycle using a nuclear/ gasification hybrid plant as long as emissions capture is used. The two primary factors that will decrease the cost per GGE for the product fuels are the levelized cost of electricity and the efficiency of the electrolysis equipment. Both of these parameters remain uncertain quantities, as the technologies are in their infancy and have not yet been commercialized on a large scale. Regardless of the uncertainty in the values the results indicate that significant improvements in levelized cost of energy from an SMR and electrolysis efficiency would need to be realized in order to make a viable business case. As the cost of diesel fuel rises in future and with any government incentives designed to restrict fossil fuel usage these technologies could be economically comparable to the shipping of fossil fuels. It should also be noted that the use of an SMR and small size equipment, while producing less throughput allows for a smaller initial capital investment. This may be of value if some upfront funds are available to initiate a project and quick fuel production is desired.

Due to the ease of dispatching diesel or natural gas fuels it is possible that the proposed cycles could be used as energy storage mechanisms when linked to a grid powered by a nuclear reactor. In this concept the synthetic fuel production cycle would be engaged when the power supplied by the reactor exceeded the communities demand, the fuel produced is easily stored or transported with equipment that is well commercialized. When the load demand rises above the capacity of the nuclear generation, supplementary electricity would be generated by burning fuel, produced in low demand periods. The by-product carbon dioxide from the combustion of this fuel could be captured and re-circulated for use in producing more fuel in low demand periods. Hydrogen has frequently been proposed for grid storage; however the storage of hydrogen and electric recovery in a fuel cell is not as developed as the storage and combustion of diesel fuels. The cost of hydrogen production versus the cost of synthetic diesel fuel production is very comparable per GGE. The efficiency of a fuel cell exceeds that of an internal combustion engine, but depending on the end use and the difficulty of storage, transportation, and dispatch for hydrogen the conversion to a diesel fuel may prove more economic in some cases.

7. References

[1] C.Higman, M. van der Burgt, "Gassification", Elsevier Inc, Burlington MA, 2008.

[2] P. Pfeifer, "High-Temperature / High-Pressure Water Gas Shift Reaction to increase the H2 / CO-ratio in syngas from biomass Gassification, Karlsurhe Institute of Technology, Karlsruhe, Germany, 2015.

[3] Audi Media Center, "Fuel of the Future : Research Facility in Dresden Produces First Batch of Audi E-diesel", Dresden, Germany, April 21 2015.

[4] APS Panel on Public Affairs, "Direct Air Capture of CO_2 with Chemicals", APS Physics, June 1, 2011.

[5] A. Eisenberg, "Pulling Carbon Dioxide out of Thin Air", http://www.nytimes.com/2013/01/06/business/pilot-plant-in-the-works-for-carbon-dioxide-cleansing.html?_r=2&, Jan 5 2013.

[6] J. Ralston, "The Sabatier Reaction, Possible Solution to CO_2 Emissions", Penn Energy, Tulsa, OK, United States, 2010.

[7] A. Abdulla, "Developing a range of levelized cost estimates for integral lightwater small modular reactors"

[8] G. Saur and T. Ramsden, "Wind Electrolysis: Hydrogen Cost Optimization" Technical Report NREL, Golden Colorado, US, May 2011.

[9] U. Vogt, F. La Naour, P Baurens, S. Ebbesen, "IEA/HIA task 25: High Temperature Hydrogen Production Process"

[10] R.M. Swanson, "Techno-economic Analysis of Biomass –to-liquids production based on Gasification" Graduate Thesis, Iowa State University, United States, 2009.

[11] California Energy Commission, "Gasoline Gallon Equivalent for Alternative Fuels", http://www.energyalmanac.ca.gov/transportation/gge.html, 2008

[12] E. Konarek, J. Eastick, "Small Modular Reactors for the Production of Hydrogen Fuel at Remote Sites". CNS Conference, Toronto, Canada, 2016.

[13] Ontario Power Authority, "Draft Technical Report and Buisness Case for the Connection of Remote First Nation Communities in Northwest Ontario" OPA, Ontario, Canada, Aug 21, 2014.

[14] Canadian Gas Association, "Gas Stats" http://www.cga.ca/gas-stats/ , CGA, Ottawa, Canada, 2016.

Radiation by The Numbers: Developing an On-Line Canadian Radiation Dose Calculator as a Public Engagement and Education Tool

by M.T.J. DALZELL[1]

Abstract

Concerns arising from misunderstandings about radiation are often cited as a main reason for public antipathy towards nuclear development and impede decision-making by governments and individuals. A lack of information about everyday sources of radiation exposure that is accessible, relatable and factual contributes to the problem. As part of its efforts to be a fact-based source of information on nuclear issues, the Sylvia Fedoruk Canadian Centre for Nuclear Innovation has developed an on-line Canadian Radiation Dose Calculator as a tool to provide context about common sources of radiation. This paper discusses the development of the calculator and describes how the Fedoruk Centre is using it and other tools to support public engagement on nuclear topics.

Keywords: Radiation awareness, education, engagement, outreach

1. Introduction

Concern and fear of ionizing radiation arising from misunderstanding is frequently cited as one of the main reasons for antinuclear sentiments in the general population, which in turn impedes decision-making by governments. For example, fear of radiation in the aftermath of the tsunami-induced accidents at Fukushima Daiichi has been identified in criticisms of the evacuation effort of surrounding communities, which resulted in fatalities and ongoing deleterious impacts on the health and economic well-being of evacuees. [1]

A lack of information about everyday sources of radiation exposure that is accessible, relatable and factual contributes to public misunderstanding and fear. As part of its mandate to be a fact-based source of information on nuclear issues, the Sylvia Fedoruk Canadian Centre for Nuclear Innovation (Fedoruk Centre) identified a need to address misunderstandings related to radiation as part of its public engagement and outreach activities. Central to this effort is the communication of three main understandings:

- Radiation is a natural part of the environment;
- We are exposed to natural and artificial sources of radiation every day; and
- People are normally exposed to doses of radiation as the result of where and how they live.

1.1 An online annual dose calculator

The Canadian Nuclear Society (CNS), Canadian Nuclear Safety Commission (CNSC), Health Canada and other agencies and organizations feature information on their websites on radiation. While this information is generally accessible and accurate, it was felt that a tool that was more interactive and which could be related to on a personal level by Canadians would be useful. The American Nuclear Society (ANS) maintains a Radiation Dose Chart on its website [2] that identifies common sources of ionizing radiation and then tallies total annual exposure based on an individual's responses and inputs based on a number of geographic, lifestyle and medical factors. However, as it is tailored for a U.S. audience, the ANS chart is not ideal as an outreach tool for Canadians. To address this need, the Fedoruk Centre developed the Canadian Radiation Dose Calculator (Figure 1).

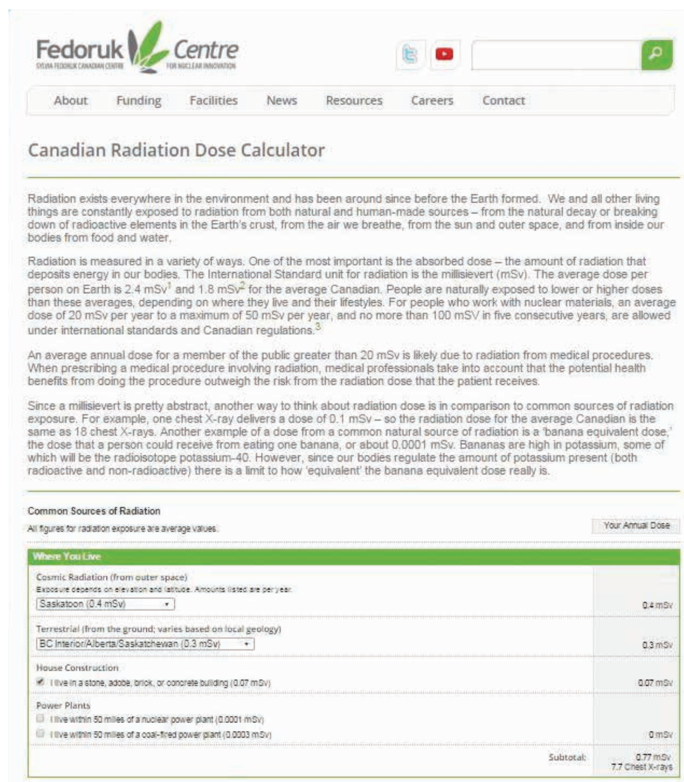

Figure 1. Screen shot of the Canadian Radiation Dose Calculator

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Figure 2. Screen shot displaying the 'Where You Live' field of the CRDC, including cosmic radiation and terrestrial radiation inputs.

2. Canadian Radiation Dose Calculator

The ANS graciously provided the Fedoruk Centre with the code for their dose chart and granted permission for its modification and 'Canadianization.' Like the ANS Dose Chart, the Canadian Radiation Dose Calculator (CRDC) classifies sources of exposure and dose in four categories:

- "Where You Live:" cosmic radiation (as a function of elevation), terrestrial exposure based on geographic location, house construction, and proximity to both coal and nuclear power plants;
- "Food, Water and Air:" ingestion and inhalation exposures;
- "How You Live:" including various lifestyle factors such as hours travelled by airplane and smoking; and
- Medical Procedures.

Initially, modifications were envisioned as being limited to converting the unit used for measuring dose from millirems to millisieverts (mSv, the SI unit of radiation dose used in Canada), and entering terrestrial exposure values for Canadian localities. Since a millisievert is as abstract as a millirem, it was decided to also present the user's final dose in banana equivalents (1 mSv ≈ the dose that would be received from the decay of potassium-40 in 10,000 bananas). Exposure data for Canadian localities were obtained from the Canadian Nuclear Safety Commission's website [3] and supplemented by values published by Grasty and LaMarre (2004) [4]. However, the modifications were not as straight forward as initially assumed, particularly in determining cosmic, terrestrial and inhalation exposures. This was due to several factors that are discussed for each exposure category below, with the greatest single difficulty being the lack of consistent dose values for representative localities across Canada.

2.1 Cosmic radiation exposure

The ANS Dose Chart calculates cosmic radiation dose strictly as a function of elevation above sea level, based on the assumption that dose from cosmic radiation is lower at lower elevations due to atmospheric absorption. [3] While this generalization is a useful rule of thumb and may indeed be an acceptable approximation for the continental United States, it is not completely accurate due to variations caused by latitude, with localities at higher latitudes receiving a slightly higher cosmic radiation dose regardless of elevation. This was addressed by providing the user with the option of selecting the Canadian average annual exposure of 0.3 mSv or selecting from a list of major Canadian cities (Figure 2). This approach also has the advantage of not requiring users to know the elevation of their city.

2.2 Terrestrial exposure

Natural background radiation from terrestrial sources comes principally from radioisotopes in the soil and in building materials, most notably potassium-40 and products of the uranium-238 and thorium-232 decay series ([4], pg. 215). Values published by the CNSC [3] for selected Canadian communities were used. An inspection of the values combined with observations from the "Radioactivity Map of Canada" [5] compiled by the Geological Survey of Canada showed similari-

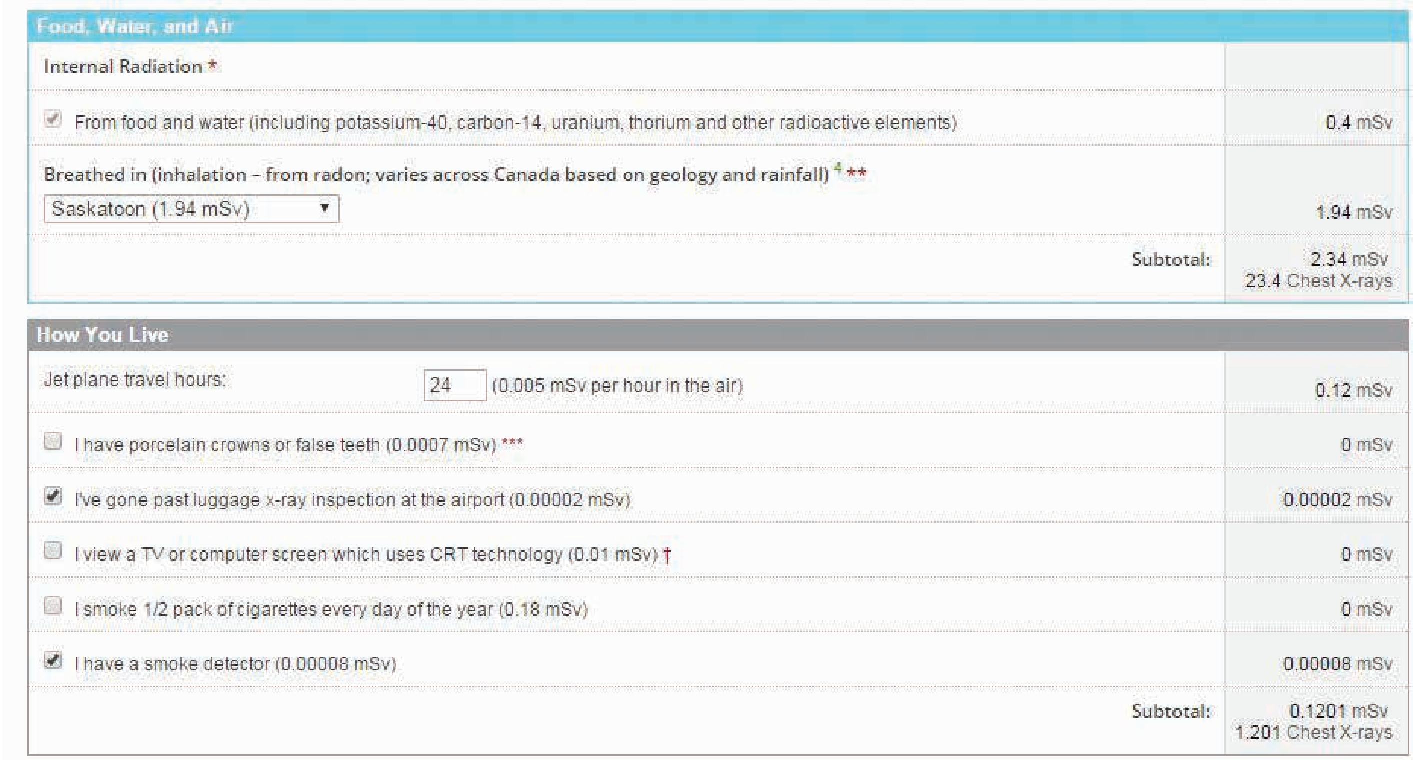

Figure 3. Screen shots of the internal/inhalation exposure fields and the lifestyle exposure fields.

ties in terrestrial background radiation in a number of regions, leading to the decision to portray a set of regional values rather than for specific communities. This approach is similar to that taken in the ANS Dose Chart, providing a reasonable approximation of dose while making the tool more accessible to users who do not reside in the listed communities. The Canadian annual average is offered as the default option.

2.3 Inhalation exposure

In the CRDC, inhalation exposure is grouped with internal exposure – the dose received from the decay of radionuclides introduced into the body by eating and drinking (Figure 3). This includes potassium-40, carbon-14 and the aforementioned uranium and thorium decay series, accounting for an annual dose of 0.4 mSv. Inhalation exposure comes primarily from the decay of radon-222 and radon-220 (thoron). The concentration of radon in the environment, both indoors and outdoors, varies across Canada based on geology (from the presence of radiogenic minerals) and precipitation (with more arid regions having higher concentrations of radon) [4,6].

The annual inhalation doses used in the CRDC were taken from Grasty and LaMarre (2004), which were derived from the calculation of inhalation doses of radon-222 from both indoor and outdoor concentrations, measured as part of Health Canada studies using dose conversion factors recommended by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) ([4], pg. 222). The contribution of radon-220 to total inhalation dose was also calculated by Grasty and LaMarre using the ratio of worldwide annual effective dose from radon-222 to radon-220, published by UNSCEAR (2000) as 1.15 to 0.10 mSv. [7]

The annual outdoor, indoor and total inhalation doses for 16 Canadian cities were published by Grasty and LaMarre as a figure ([4], Figure 7). However, only values for some localities in the figure were published. This resulted in the recalculation of the values following the UNSCEAR equations and radon-222 values given. Discrepancies between calculated and published doses ([4] Table 8) were brought to the attention of Dr. Grasty, who provided corrected values (Grasty, 2015, pers. comm.). Annual inhalation doses for localities for which cosmic ray doses could be obtained were included in the calculator, along with a Canadian average of 0.9 mSv.

2.4 Other categories

Other sources of radiation exposure based on lifestyle factors (e.g. hours of travel by jet, smoking) (Figure 3) and medical diagnostic procedures (Figure 4) were ported from the ANS Radiation Dose Chart and converted to mSv.

3. Beta testing and feedback

The link to a beta version of the CRDC was sent to a focus of group involved in physics, engineering, medicine, education and science communications. The feedback received was valuable and resulted in a number of improvements to the calculator, including:

- Addition of a dial graphic that displays the user's calculated annual dose in relation to the average dose for a person on Earth (2.4 mSv/yr), Canadian average (1.8 mSv/yr; also the calculator's default value), and an average for a Nuclear Energy Worker (20 mSv/yr; 1/5 of the 5-year regulatory maximum exposure of 100 mSv) (Figure 5);
- The portrayal of dose for each category in mSv and in chest X-ray equivalents (where 1 chest X-ray = 10 mSv); and
- Additional commentary and links to external resources to address concerns that might be expressed by a user whose annual dose comes in substantially higher than the displayed average, which would most likely be due to dose received from medical procedures.

4. Conclusions

The CRDC is intended to be a tool that demonstrates that radiation is part of the environment that is encountered every day. It is hoped that it, along with other factual resources, can contribute to wider conversations about risk and nuclear technology.

Figure 4. Screen shot listing radiation exposures of common nuclear medicine and radiological procedures.

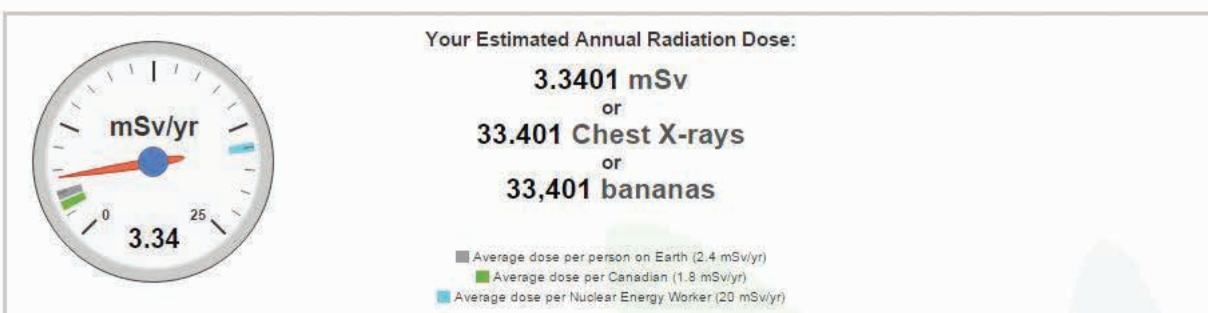

Figure 5. Screen shot of the summary field of the CRDC, showing the estimated annual radiation dose for an individual living in Saskatoon, Saskatchewan, who lives in a brick building, flew 24 hours by jet, owns a smoke detector and underwent chest, dental and extremity medical X-rays.

5. Acknowledgements

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6. References

1. Johnson, George. "When Radiation isn't the Real Risk, " *New York Times*, September 21, 2015, pg. D3. http://www.nytimes.com/2015/09/22/science/when-radiation-isnt-the-real-risk.html?ribbon-ad-idx=5&rref=-science&_r=0 Accessed September 23, 2015.
2. American Nuclear Society. Undated. "Radiation Dose Chart." http://www.ans.org/pi/resources/dosechart/
3. Canadian Nuclear Safety Commission. "Introduction to Radiation: Radiation Doses." http://nuclearsafety.gc.ca/eng/resources/radiation/introduction-to-radiation/radiation-doses.cfm Last modified 2015-01-19. Accessed and archived 2015-06-16.
4. Grasty, R.L. and LaMarre, J.R. 2004. "The Annual Effective Dose from Natural Sources of Ionising Radiation in Canada," *Radiation Protection Dosimetry*, 108, 3, pp. 215-226.
5. Buckle, J.L., Carson, J.M., Ford, K.L., Fortin, R. and Miles, W.F. 2014. "Radioactivity Map of Canada, Natural Air Absorbed Dose Rate." Geological Survey of Canada Open File 7396.
6. Canadian Nuclear Safety Commission. 2013. "Natural Background Radiation." http://nuclearsafety.gc.ca/eng/resources/fact-sheets/natural-background-radiation.cfm.
7. United Nations. 2000. *United Nations scientific committee on the effects of atomic radiation (UNSCEAR), report to the General Assembly*. New York: United Nations.

Applications of Nuclear Safety Probabilistic Risk Assessment to Nuclear Security for Optimized Risk Mitigation

by S.K. DONNELLY[1] and S.B. HARVEY[1]

Abstract

Critical infrastructure assets such as nuclear power generating stations are potential targets for malevolent acts. Probabilistic methodologies can be applied to evaluate the real-time security risk based upon intelligence and threat levels. By employing this approach, the application of security forces and other protective measures can be optimized. Existing probabilistic safety analysis (PSA) methodologies and tools employed in the nuclear industry can be adapted to security applications for this purpose. Existing PSA models can also be adapted and enhanced to consider total plant risk, due to nuclear safety risks as well as security risks. By creating a Probabilistic Security Model (PSM), safety and security practitioners can maximize the safety and security of the plant while minimizing the significant costs associated with security upgrades and security forces.

1. Introduction

Risk informed decision making processes are applied in many industries. More sophisticated applications utilize a probabilistic assessment methodology, allowing for quantification of residual risk. While Probabilistic Safety Assessments (PSA) are commonly used in highly regulated industries such as the nuclear power generating industry to quantify risks to public safety, many other industries and organizations employ a Threat and Risk Assessment (TRA) to identify and quantify security risk. The Harmonized TRA of the Communications Security Establishment (CSE) and Royal Canadian Mounted Police (RCMP) [1] provides a comprehensive TRA methodology. Most organizations will utilize a more basic approach, tailored to the complexity of their operating environment.

A TRA is typically divided into a number of phases, which are presented in Figure 1. While a TRA is intended to identify and quantify threats, evaluate their frequency of occurrence, the consequences, residual risk and mitigation measures, it does not typically consider optimization of human interactions (e.g., security forces or operations staff) to mitigate the risk. This paper focuses on this aspect, namely the optimization of the complex interactions associated with security forces, inherent safety and security design features. This activity has been termed a Probabilistic Security Model (PSM) and aims to increase the efficacy of a security force and minimize operational cost and complexity.

2. Background

PSAs and TRAs are common in many industries. Utilities and particularly large electrical generating sta-

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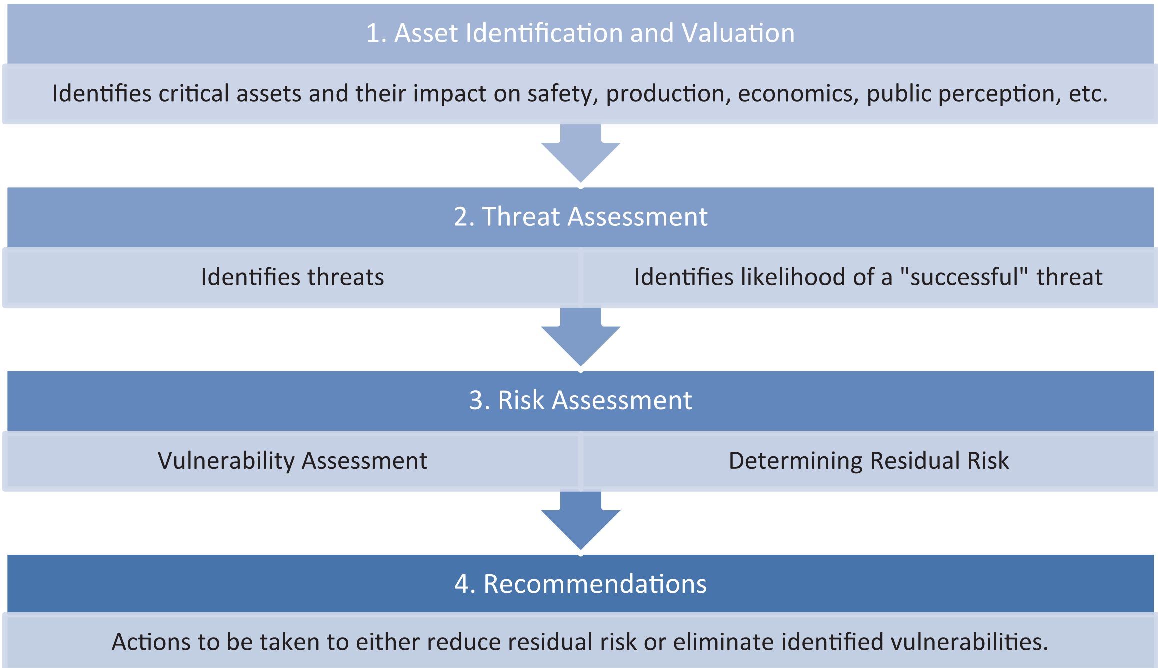

Figure 1: Typical phases of a Threat and Risk Assessment.

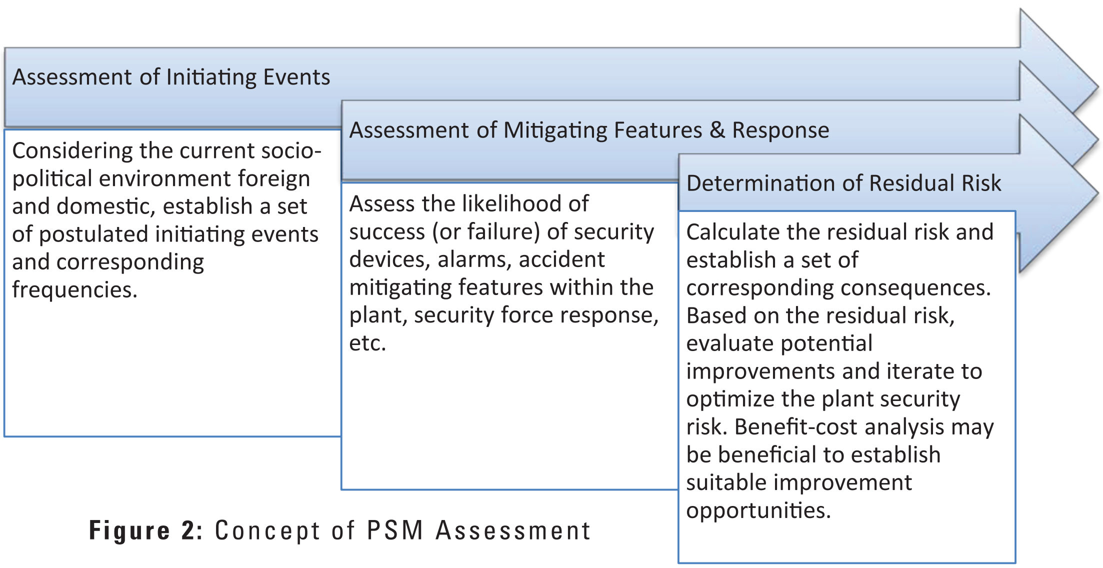

Figure 2: Concept of PSM Assessment

tions utilize such tools to minimize public and economic risk. Substantial financial investments have been made to develop the PSAs for Nuclear Power Plants (NPPs); a basic PSA is likely to cost several millions of dollars. However, utilities and regulators worldwide recognize the benefits of such studies in reducing public risk by identifying and quantifying risk, thereby allowing for the reduction of risk.

NPP PSAs are used to support a wide variety of design, maintenance, operational, and safety analysis aspects; however, security-related applications are not one of the typical uses and are not considered in international guidance such as Reference [2]. Most other PSA-related guidance and regulatory documents are also silent on security applications. This absence in readily available guidance can at least be partially be attributed to the fact that practitioners of PSA and those responsible for nuclear security are organizationally separated. Further, the potentially sensitive nature of both focus areas does not lend well to information sharing; hence, there may not be an awareness of the potential interactions of the two areas.

Probabilistic tools represent a valuable tool for enhancing protection from threats such as malevolent acts, particularly security events with the potential to impact public safety for which NPP PSAs were intended. Of note is that in some jurisdictions, the NPP PSA is classified as security sensitive due to the potential to identify vulnerabilities that could be used to exploit sensitive aspects.

2.1 Overall vulnerability assessment

A PSM can identify the relative strengths and weaknesses of both the overall and individual parts of the security systems including alarm functions, video threat assessment, and communication, through to various layers of security responder intervention.

A PSM can be used to identify attack locations in terms of attractiveness of the targets and the specifics of the security measures which may be effective to mitigate the risk of such sequences (e.g., protective devices, security forces, alarms). However, by combining a PSM with the plant PSA, the consequences of such an event should it occur can be explicitly evaluated and the risk reduction associated with security improvements can be evaluated. The use of the PSM along with the PSA provides the most comprehensive solution for optimizing protection and response.

Depending on how a PSM is built, it may be possible to identify implications of adversary damage done in geographic areas. For example PSAs used to assess fire damage can predict for a given fire location which components and sub-systems may be affected. Such affects consider both direct damage due to fire and indirect damage such as compromising electrical cables to remote equipment that run through the area affected. Similar approaches have been used in security studies to assess impact of postulated aircraft crashes or explosions of specified magnitudes and consequent damage radii.

The overall PSM assessment process is shown in Figure 2. The subsequent sections describe each of these stages in more detail.

2.1.1 Assessment inputs

A PSM requires sufficient information pertaining to the threat and the expected probability of success of various robustness features or mitigation actions.

The threat itself must be established with sufficient clarity to define the characteristics of the threat (e.g., adversary capability). Security threats for a nuclear facility could involve a wide spectrum of adversary capabilities. For example, a more likely threat would be that of an environmental activist group wishing to vandalize a portion of the plant for media attention. The frequency of occurrence of a threat can be established through assessment of similar events worldwide and an assessment of the domestic "environmental terrorist" threat. A less likely, but potentially much more harmful threat could entail a terrorist cell with access to significant funding, insider knowledge, and the means to carry out a significant attack. In addition to use of the PSM with a range of assessed threat frequencies, the PSM can alternately be used with a given threat set as a certainty, and then the likelihood of various adverse consequences as a result of mitigation measures can be assessed.

Once the threat is established and a suitable security "initiating event" frequency is established, the PSM requires that the analyst evaluate the various barriers which would mitigate the potential consequences. Such barriers may include factors such as physical barriers (e.g., delay barriers), civil/structural factors (e.g., target hardening, wall thicknesses), intrusion detection and other alarm systems, response force personnel, and the physical facility layout. Each of these factors must be systematically assessed to determine the likelihood of success of the protective features or measures.

Although this approach can be adopted using a static plant condition, use of actual operational conditions, and real-time threat levels can allow security and PSA practitioners to assess the specific security risk profile of the plant in any condition at any point in time. This is highly effective at addressing changing risk levels due to political and world events. For example, the terrorist risk rating can be used as an input to the model to evaluate the change in plant risk due to a change in terrorist activity or chatter.

2.1.2 Assessment tools

Tools developed for PSAs can be adapted to use with a PSM. These include the Fussell-Vesely (FV) importance measure which represents the ratio of the decreased risk level if a component (in the case of a PSM this would be an element of the security system) is assumed never to fail to the reference risk calculated from the PSM. Risk Achievement Worth (RAW) is another PSA importance tool that could be applied to a PSM. RAW assesses the impact on system reliability of a component of the system that is assumed to be failed. It is a measure of the worth or importance of a given component in achieving the system's macroscopic reliability. In essence, a component is shown as being failed in the PSM and then the model is solved to assess the impact on the security system. The Risk Reduction Worth (RRW) can also be utilized, signifying the reduction in overall risk if the component failure was to never occur.

There are other importance measures beyond the three described above that can be applied to specific applications. In all cases, use of importance measures requires a degree of expertise since it is both possible to misinterpret individual importance measures, and importance measures can be computationally challenging unless carefully chosen simplifying assumptions are applied.

Depending on the type of protective feature or measure, one or more of these PSA tools may be better suited to characterize the significance. For example, a large FV will indicate that improving the robustness or effectiveness of a particular protective feature or response will have a significant effect on mitigating the residual risk. Other importance measures can provide similar insights.

2.2 Minimizing Risk

2.2.1 Mitigation following failures

Security systems typically have established processes to be applied following failure of one part of the system. For example if an alarm system is failed, a security officer may be posted to provide oversight that the alarm would otherwise provide. A PSM can be used to identify strategies to cater to component failures that provide the largest security benefit at the lowest cost. This could be useful if a new vulnerability is identified through operating experience at other facilities or if the Design Basis Threat is changed. The PSM can identify what parts of the security system are most important given a particular new or increased likelihood of an existing threat is postulated.

2.2.2 Human reliability

One of the significant advancements in the field of PSA is the understanding of the impact of humans on system reliability. This is important to any risk assessment since humans have a dominant effect on the effectiveness of detection and mitigation functions, whether in the plant reliability context or in the security context. The methodologies to model human performance developed for plant level risk assessments can be directly applied to security. They involve assessing factors such as the complexity of decision making, the nature of information presented, the complexity of the human-machine interface, and the time demands in which decisions and reactions must occur.

As an example, similar approaches to the modelling of plant operator reliability in the context of a PSA could be applied to modeling of security staff in Security Monitoring Rooms. Like the plant control room, security staff in the Security Monitoring Rooms are absolutely essential to the outcome of a security event. A human reliability model as part of a PSM can identify areas where staff in the Security Monitoring Rooms would benefit from improvements that increase their ability to process information in a high-stress situation and to perform their role as a critical link in the ability of responders to defend where needed.

2.2.3 Optimization of use of existing assets; identifying impact of changes to assets

For a given existing set of security systems and resources, it is possible to use a PSM to optimize deployment. For example, the deployment of security foot or vehicle patrols by geographic sector can be optimized based on risk to the plant posed by intrusion in various sectors. A probabilistic model would show that a sector that is inherently protected by geographic features or which is remote from sensitive plant areas, would get less benefit from patrols than areas that do not have the same inherent security advantages. A randomized patrol schedule could then bias upward patrol time spent in the more sensitive sectors to optimize the risk profile across all sectors.

Depending on the detail of the PSM, it could also be possible to compare the relative importance of foot patrols, vehicle patrols, and automated systems to optimize the resourcing.

The PSM can be used to assess the security value of expenditures. This could include assessing the security risk reduction as a result of adding an armoured vehicle patrol, or adding an additional Security Monitoring Room operator. Similarly the adverse impact of resource reductions can be assessed and the least impactful areas to make reductions can be identified.

Reliability targets for safety systems are typically established in a nuclear plant to identify during system design, the amount of redundancy required and the required reliability of individual components or sub-systems. Targets also influence the frequency of testing that must be performed and flag when repeated component or system failure is reaching a level where improvements are required. Historically such targets were developed deterministically but it is now possible to develop system targets based on the plant risk model. The same is possible for security systems based on the use of a PSM. Such targets can be used to specify or validate testing frequencies of components. Over-testing is a waste of resources and can cause premature wear out of components. Under-testing reduces reliability. Targets allow for an appropriate response to individual failures by identifying when such failures are within bounds of anticipated failure rates or are indicative of components that are entering end of life and need to be replaced.

3. Conclusions

The approach to nuclear safety continues to evolve with the use of probabilistic methods in addition to classical deterministic approaches. This shift acknowledges that all scenarios cannot be fully postulated and that bounding design basis events are not always representative of the worst case due to unknowns. As security risks continue to change, the design basis threat approach becomes more complex and requires frequent change to adapt to changing security risks. Furthermore, as with nuclear safety, design basis threats may not fully reflect the worst case due to unknowns and the development of more and more complex aggressor strategies.

Probabilistic methods provide options for the evaluation of these threats: directly from existing PSA for identification of security vulnerabilities or the use of PSA methods to develop a separate or complimentary PSM. A PSM can be used to determine the dynamic security risk profile and adapt security forces and mitigation measures to minimize risk.

The benefits of well-established PSA tools have been proven for nuclear safety applications and help to improve plant nuclear safety and therefore public safety. These tools can be adapted and applied in the nuclear security context to further improve nuclear safety and public safety from the perspective of security. Many of the benefits of PRA for enhancing Nuclear Safety can be achieved using a stand-alone PSM or a PSM and PSA together to enhance Nuclear Security. These models provide new capability to enhance and optimize the security design and response capability for the facility.

4. References

[1] Communications Security Establishment & Royal Canadian Mounted Police, "Harmonized Threat and Risk Assessment Methodology", TRA-1, 23 October 2007.

[2] International Atomic Energy Agency, "Applications of probabilistic safety assessment (PSA) for nuclear power plants", IAEA-TECDOC-1200, February 2001.

Abstracts

The following are abstracts of papers presented at the 36th Annual Conference of the Canadian Nuclear Society and 40th Annual CNS/CNA Student Conference in Toronto, ON, Canada, June 19-22, 2016. Requests for copies should be directed to the authors.

Outreach and Engagement Activities to Support Nuclear Conversatons

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The Fedoruk Centre has embarked on a strategic communications and outreach campaign to encourage fact-based discussions about topics related to nuclear technology and sustainability. The objective of the campaign is to position the Fedoruk Centre as a source of factual information and a gateway to expertise about the benefits and risks of nuclear technology for the people of Saskatchewan. It aims to involve publics and stakeholders within Saskatchewan in forms of upstream engagement, providing access to information about common concerns of nuclear development, such as radiation, while also working to challenge and correct misinformation in the public space and the media. It will also inform and be informed by research into societal engagement involving complex technological issues being undertaken by the Johnson-Shoyama Graduate School of Public Policy. This paper discusses the conceptual development of the campaign's strategy, results of initiatives and activities that have been undertaken and future plans.

Keywords: nuclear awareness, education, engagement, outreach, communications, public relations

Implementation of Enhanced Severe Accident Management Guidance at OPG and Bruce Power

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As a part of the post-Fukushima response, OPG and Bruce Power have enhanced their SAMG programs to provide the capability to respond to a wider range of event progressions such as multi-unit events or IFB events. In many instances, these enhancements were adapted directly from a COG Joint Project undertaken by the CANDU industry. However, as a part of the station-specific SAMG updates, opportunities were identified to enhance the practical implementation of the COG recommendations. Most notably, these include an alternative approach to managing IFB events, a simplified approach to hydrogen management, and guidance on comparing between containment venting and leakage at elevated pressures. These enhancements are being exercised through a combination of tabletop exercises and drills to confirm usability. The outcome of this process is a SAMG program that retains key features from the COG work in a format that is readily integrated into the pre-existing SAMG for each station.

A Phased Approach to Human Factors Integration – Point Lepreau EME Deployment Case Study

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Following CNSC Regulatory Policy *P-119 - Policy on Human Factors*, all Canadian utilities licensed by the

Canadian Nuclear Safety Commission (CNSC) are required to consider human factors in all phases including design, construction, commissioning, operation, maintenance and decommissioning. In conducting human factors assessments of design modifications, utilities generally consider human factors during the design phase as part of the engineering change control process. However, performance of human factors assessments before and/or after the design phase can be more effective and reduce unnecessary engineering effort. A recent human factors assessment performed at the Point Lepreau Nuclear Generating Station demonstrates some of the synergies that can be achieved by using a phased approach to human factors assessments. This case study is presented as evidence that a phased approach to human factors integration has merit and should be considered in the future by the industry.

Coupling RELAP5 and Pressure Tube Deformation Models to Analyze the Thermal-Mechanical Phenomena in Candu Severe Accidents

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During the channel heat-up phase of postulated severe accidents in CANDU reactors, the pressure tube may balloon or sag into contact with its calandria tube depending on the internal pressure. If the channel is surrounded by the moderator, this contact will establish an effective heat sink to the moderator. If the channel is uncovered, the fuel channel assembly will sag or disassemble. These phenomena, which have significant effects on accident progression, however, are not mechanistically modeled by most existing severe accident codes. Three channel deformation models based on existing phenomena in literature have been coupled to RELAP5 to provide more robust treatment of the deformation phases of severe accidents. Two coupling methods are used: one uses a Python script to externally couple these models with RELAP5/Mod3.3; in the other method, the models are compiled into RELAP/SCDAPSIM/ Mod3.6 as new SCDAP subroutines. The main objectives of this paper are to introduce these models and the coupling methods, and to benchmark them against several PT deformation experiments.

Seismic Fragility Analysis of a Nuclear Building Based on Probabilistic Seismic Hazard Assessment and Soil-Structure Interaction Analysis

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Seismic fragility analyses are conducted as part of seismic probabilistic safety assessment (SPSA) for nuclear facilities. Probabilistic seismic hazard assessment (PSHA) has been undertaken for a nuclear power plant in eastern Canada. Uniform Hazard Spectra (UHS), obtained from the PSHA, is characterized by high frequency content which differs from the original plant design basis earthquake spectral shape. Seismic fragility calculations for the service building of a CANDU 6 nuclear power plant suggests that the high frequency effects of the UHS can be mitigated through site response analysis with site specific geological conditions and state-of-the-art soil-structure interaction analysis. In this paper, it is shown that by performing a detailed seismic analysis using the latest technology, the conservatism embedded in the original seismic design can be quantified and the seismic capacity of the building in terms of High Confidence of Low Probability of Failure (HCLPF) can be improved.

Keywords: Seismic fragility, risk assessment, seismic hazard, ground motion, uniform hazard spectra, soil-structure interaction, dynamic model, CANDU 6.

GENERAL news

(Compiled by Colin Hunt from open sources)

CNSC Issues a Decommissioning Licence for the Gentilly-2 facility

Following a public hearing held in Ottawa, ON on May 5, 2016, the Canadian Nuclear Safety Commission (CNSC) announced on June 22 its decision to issue a power reactor decommissioning licence to Hydro-Québec for the Gentilly-2 facility located in Bécancour, QC. The licence will be valid from July 1, 2016 to June 30, 2026.

During the public hearing, the Commission received and considered submissions submitted by Hydro-Québec and five intervenors, as well as the recommendations of CNSC staff.

The CNSC issued a power reactor decommissioning licence to Hydro-Québec for the Gentilly-2 facility, which is valid from July 1, 2016 to June 30, 2026. The Gentilly-2 nuclear power plant was permanently closed in December 2012.

Gentilly Nuclear Power Station.

IAEA OSART Mission Report to Canada Now Available

On May 13, 2016, Bruce Power made available the full report of the International Atomic Energy Agency (IAEA) Operational Safety and Review Team (OSART) mission conducted at the Bruce B Nuclear Generating Station from November 30 to December 17, 2015. The purpose of the mission was to review operating practices in the areas of leadership and management for safety; training and qualification; operations; maintenance; technical support; operating experience feedback; radiation protection; chemistry; emergency preparedness and response; accident management; interactions between human technology and organization, and long-term operations. The OSART team concluded that Bruce Power is committed to improving the operational safety and reliability of the plant. The team outlined good areas of performance, such as the development of an effective overall technical strategy to manage reactor safety and the use of a wide range of engaging training settings to provide learning and development opportunities to employees. In total, the report identifies 10 good practices, 25 good performances, 12 suggestions and 5 recommendations.

Bruce Power is meeting all current regulatory requirements, and the recommendations and suggestions of the OSART mission report are considered to be improvements to existing safe practices.

The Bruce Power OSART mission was conducted at the request of the Government of Canada and the Canadian Nuclear Safety Commission. It was the fifth mission in Canada since 1983 and the 188th of the IAEA program, which began in 1982. The OSART team was composed of IAEA staff members and experts from Finland, France, Hungary, India, Romania, Slovakia, Sweden, the UK and the US. The collective nuclear power experience of the team was approximately 380 years.

A follow-up visit will be conducted 18 months after the initial mission. The CNSC Integrated Action Plan on the Lessons Learned from the Fukushima Daiichi Nuclear Accident called for the IAEA to conduct OSART missions at all Canadian NPPs, starting in 2015. These missions will provide opportunities for Canadian NPP operators to benefit from the dissemination of information on industry best practices and to broaden their experience and knowledge.

Read the OSART report: http://14083-presscdn-0-0.pagely.netdna-cdn.com/wp-content/uploads/2016/05/Bruce-B-OSART-report-.pdf

Read Bruce Power's letter on the OSART report: www.brucepower.com/bruce-power-osart-report/

500 Jobs Lost as Cameco Closes Rabbit Lake Mine

Cameco Corp. has shuttered its long-running Rabbit Lake operation in Saskatchewan as the company tries to adjust to an extremely weak uranium market. The shutdown will lead to roughly 500 job losses, Saskatoon-based Cameco said. The company is also curtailing production at its U.S. operations, which will result in an additional 85 job cuts. Cameco chief executive Tim Gitzel said these moves were unavoidable as the company needs to be prepared for a "lower-for-longer" scenario in the uranium business.

The company is ramping up production at its very low-cost Cigar Lake mine. That means it can meet its customers' needs without the higher-cost output from Rabbit Lake. The job cuts are another blow to the Saskatchewan economy. Uranium has been in a bear market since the Fukushima nuclear disaster in March 2011. In 2016, the spot price dropped to an 11-year low below US$26 a pound. It was above US$130 at the peak of the market in 2007.

Court Dismisses Appeal Against Darlington Refurbishment

Canada's Federal Court of Appeal has unanimously dismissed a judicial review of the environmental assessment (EA) for Ontario Power Generation's (OPG) planned refurbishment of the Darlington nuclear power plant. The lawsuit was brought by groups led by Greenpeace Canada.

The court found that there were no gaps or errors in the 2013 EA, which determined the project would have no significant adverse effects on the public or the environment. It also found that there was "nothing unreasonable" about determinations made by the responsible authorities that reviewed the EA, and found that arguments brought by the intervenors were not borne out by evidence.

Greenpeace Canada, the Canadian Environmental Law Association, Lake Ontario Waterkeeper and Northwatch had brought the appeal against a November 2014 federal court decision to dismiss their application for judicial review.

OPG president and chief nuclear officer Glenn Jager said that the court decision was a "vote of confidence" in the quality of work that went into the EA application and in the licensing process. "We have been preparing for this project since 2009, and we're ready to deliver the job safely, on time and on budget", he said.

OPG announced the CAD 12.8 billion ($9 billion) project to refurbish the four Darlington Candu units in January, after nine years of scoping work and detailed planning. The refurbishment of the first unit will begin in October, and the project will take ten years to complete for all the units. Refurbishment will enable the units, which supply about 20% of Ontario's electricity, to continue to operate for a further 30 years.

Kim Rudd Delivers Keynote Speech at PBNC in China

Northumberland-Peterborough South MP Kim Rudd, in her position as Parliamentary Secretary for Natural Resources, gave the keynote speech to an international conference on nuclear technology in China.

The conference in Beijing, China opened April 5 with the theme *Nuclear - Powering the Development of the Pacific Basin and the World* and concludes April 9, according to a website from the hosting organizations.

In a CCTV news report from China, Rudd said nuclear technology is an important part of reducing carbon dioxide emissions, and both China and Canada are signatories to an agreement dedicated to "emission innovation" assisting countries and companies to do just that.

Before leaving on the trade junket with representatives from Canada (including Cameco with nuclear fuel production facilities in Cobourg and Port Hope), Rudd noted that Cameco had just successfully secured a significant Chinese contract.

Parliamentary Secretary Kim Rud with China Energy Vice Minister Zhang Yuqing.

In a media release issued from the MP's office, Rudd is quoted as stating that she is "pleased to be (handling the nuclear file) as part of the new government: a government that stands behind evidence-based policy; a government that supports clean technology to address climate change; and a government committed to public engagement.

"What has not changed with our government is Canada's long-standing relationship with China and our history as major trading partners. In fact, trade between our two countries topped $85 billion last year, and China was second only to the United States as a destination for Canadian exports."

Takahama Units Cleared for Extended Operation

The Japanese nuclear regulator has approved the operation of units 1 and 2 of Kansai Electric Power Company's Takahama nuclear power plant for up to 60 years. They become the first Japanese units to be granted a licence extension beyond 40 years under revised regulations.

Takahama 1 and 2 are progressing through the restart process. In April, the Nuclear Regulatory Authority confirmed the units meet new safety regulations. The units are the oldest of the seven reactors so far deemed to conform to the new safety standards.

EdF CEO Says Brexit to Have No Effect on Nuclear Development in UK

EDF Chief Executive Officer Jean-Bernard Lévy said the UK's decision will have no impact on EDF Energy's strategy to build Hinkley Point C - the first new nuclear power station built in the UK in almost 20 years. Scheduled to begin operating in 2025, the twin-unit UK EPR plant will provide about 7% of the UK's electricity.

"As of today, we believe that this vote has no impact on our strategy, and the strategy for our UK subsidiary [EDF Energy] has not changed. Our business strategy is not linked to Great Britain's political affiliation with the European Union, so we have no reason to change it," Lévy said. "I would just point out that in the last few days, spokespeople on energy issues for the Brexit camp - notably Energy Minister Andrea Leadsom - have on numerous occasions and again in recent days come out in favour of maintaining the decarbonisation policy, of maintaining the nuclear option, and of maintaining the Hinkley Point project. Therefore there are no consequences from this vote today.

"We operate in the markets like any [other] large company, and we made sure that we did not take a position one way or the other. That means that we are in a neutral position vis-à-vis the movements that could occur in the markets," Lévy continued. "Market analysts believe that the pound will drop, but if the currency falls, the economy becomes more competitive. I think we need to adapt to economic conditions and to exchange rates, which can evolve."

Under a deal agreed last October, China General Nuclear will take a 33.5% stake in EDF Energy's £18 billion ($28 billion) project to construct the plant. In addition, the two companies will develop projects to build new plants at Sizewell in Suffolk and Bradwell in Essex, the latter using Chinese reactor technology. EDF's share in the project stands at 66.5%, but the company said it intends to offer other investors stakes in the project. However, it plans to retain at least a 50% stake itself. A final investment decision on the Hinkley project is expected in September.

PG&E to Close Diablo Canyon Nuclear Plant by 2025

Pacific Gas & Electric (PG&E) has outlined plans to close its twin-unit Diablo Canyon nuclear power plant in California, reflecting the US state's "changing energy landscape". PG&E announced a 'joint proposal' with labour and leading environmental organizations that would increase investment in energy efficiency, renewables and storage beyond current state mandates while phasing out PG&E's production of nuclear power in California.

PG&E intends to operate the plant to the end of its current operating licenses, which expire on 2 November, 2024 for unit 1, and 26 August, 2025 for unit 2. The company announced its commitment to a 55% renewable energy target in 2031.

PG&E Corporation Chairman, CEO and President Tony Earley said: "California's energy landscape is changing dramatically with energy efficiency, renewables and storage being central to the state's energy policy. As we make this transition, Diablo Canyon's full output will no longer be required. As a result, we will not seek to relicense the facility beyond 2025 pending approval of the joint energy proposal."

CNS news

CNS Membership appoints large, new Council for 2016-17

by COLIN HUNT

The membership of the Canadian Nuclear Society (CNS) has appointed a large number of new members to Council at the recent Annual General Meeting of the Membership on June 19, 2016. In total, 10 new members were appointed, bringing the total number on Council to 30 for the 2016-17 term.

The new members on Council include: Farzad Ardeshiri, Chris Ciaravino, Rudy Cronk, Jerry Hopwood, Devi Shantilal, Michael Smith, Aman Usmani, Kamal Verma and Stephen Yu. Returning to Council are Parva Alavi, John Barrett, Fred Boyd, Ruxandra Dranga, Peter Easton, Mohinder Grover, Kris Mohan, Dorin Nichita, Nick Preston, John Roberts, Wei Shen, Nick Sion, Keith Stratton, Ron Thomas, and Pauline Watson. Retiring from Council at the AGM were John Cui, Jerry Cuttler, Mark Haldane, Michael Ivanco, Tracy Lapping, Jacques Plourde, Ben Rouben, Ken Smith, and Jeremy Whitlock.

The Officers of the Society for 2015 are Peter Ozemoyah, President; Dan Gammage, 1st Vice President; John Luxat, 2nd Vice President; Paul Thompson, Past President; Mohamed Younis, Treasurer; and Colin Hunt, Secretary.

In his final address to the Membership as President, Mr. Thompson noted that the CNS had a very successful year in 2015-16. The Society had achieved a strong financial performance largely as a result of the excellent results of the 2015 Annual Conference. He also noted that the Society has begun an outreach program to meet with the principals at Canada's principal nuclear utilities, research institutions and manufacturers and suppliers.

Reporting to the Membership, Mr. Thompson also noted that a Canadian, Kamal Verma of SNC Lavalin and newly elected to the CNS Council had also been elected as Vice President of the Pacific Nuclear Council.

Mr. Plourde noted that the CNS had maintained a strong program of conferences and courses during the past 12 months: the 17th International Conference on Environmental Degradation, the 7th International Conference on Simulation Methods in Nuclear Engineering, the International Nuclear Components Conference, and CW-FEST (Canadian Workshop on Fusion Energy Science and Technology).

The Annual Meeting approved a small package of minor amendments to the CNS By-Laws. These amendments are primarily items missed during the amendment of the By-Laws during the 2015 AGM.

Mohamed Younis presented the Treasurer's Report and Financial Reviewer's Report to the membership. For the second time in three years, the CNS has reported a surplus for the year.

Following the statutory portions of the AGM, Chairs of CNS Branches, Committees and Divisions tabled reports on the activities of their committees during the previous 12 months.

At the 2015 AGM in response to a question from the floor, Mr. Thompson undertook a commitment to place papers from the various CNS conferences on the CNS website. At this year's AGM, Mr. Thompson reported that the CNS had undertaken this task, and the new system was under demonstration on the CNS website at this time.

This year's AGM was well attended with nearly 50 members in attendance in person or by proxy. The meeting was held in Toronto, Ontario at the beginning of the 2016 CNS Annual Conference.

Outgoing President's Report

Last year was an exciting year for the Canadian nuclear industry. It saw positive announcements with respect to the Bruce and Darlington refurbishment project decisions, the 70th anniversary of the Canadian Nuclear Safety Commission,and the discussion on the role of nuclear power in reducing greenhouse gas emissions following the COP21 conference. Likewise, it was an exciting year for the Canadian Nuclear Society.

To kick things off, we held the 35th annual CNS conference and the 39th CNS/CNA annual Student conference in Saint John, New Brunswick, last June. Thanks to the hard work of Jacques Plourde and his organizing committee, the conference was highly successful.

We also held a Fire Safety and Emergency Preparedness conference. Based on the very positive feedback from the participants, this conference will be repeated in 2017 and future years, opening up a new networking opportunity for our members, along with a new revenue stream for the society. Thanks go out to Tracy Lapping for her vision in establishing this new conference series, and her organizing team for making FSEp·20 15 a success.

In fact last year was a banner year for conferences and courses. In addition to the two conferences discussed above, the following conferences and courses were also held:

- 17th International Conference on Environmental Degradation of Materials in Nuclear Power Plants
- 7th International Conference on Simulation Methods in Nuclear Engineering
- 2015 Canadian Workshop on Fusion Energy Science and Technology
- 20I5 International Components Conference
- CANDU Fuel Technology Course
- CANDU Technology and Safety Course
- Nuclear 101

We extend our thanks to the many volunteers who helped organize these events and to the generous support of our sponsors in making these events a great success.

This series of successful events allowed us to achieve a budget surplus when we originally expected a deficit. Overall the financial health of the Society remains strong, thanks in part to the excellent oversight of Mohamed Younis and Ken Smith. Our member equity allows us to manage our substantial cash flows without the need to borrow and pay interest charges as well as provide a cushion for the leaner years where we need to run a deficit.

Recognizing the changing environment in which we operate and the challenges it presents for the Society, the Council developed a new strategic plan and a number of initiatives to ensure we remain strong and sustainable. Thanks go to Jacques Plourde for leading Council through this exercise. One such initiative relates to relationship meetings that are being conducted with our important stakeholders. This allows us to better understand their operating environment, allows them to better understand what we can contribute to assist them and also what changes we may need to make or new opportunities we can explore.

We also made a major upgrade to the CNS Website to improve security and user friendliness. Check out the new look if you have not done so already. Any suggestions to further improve and develop the website are welcomed by Adriaan Buijs and Mark Haldane, the chairs of the internet committee, as well as Elmir Lekovic, our webmaster. One new feature that is being developed for the Website is a searchable data-base for CNS conference papers. This feature was developed in response to requests from the membership.

Branches were also very active this past year, putting on a variety of interesting technical seminars and lectures. Branch activity is the grass roots of our Society. I was pleased to be able to visit and talk with members of four of the branches over the past year.

The CNS was also very busy with its Education and Communication Outreach Program. The ability to reach out and inform members of the public and the indigenous peoples on matters relating to nuclear science and technology is very important. Dr. Jeremy Whitlock, Ruxandra Dranga, Matthew Dalzell and Ron Thomas are to be congratulated for their important contributions to this area.

The CNS submitted interventions for the Bruce and Darlington Licence renewals and the CNL application to extend the duration of the NRU Operating Licence. All of these can be found on our website.

We also continue to get good feedback on our quarterly technical publication, the CNS Bulletin. Colin Hunt as publisher and Ric Fluke as editor-in-chief continue to do a great job in producing this high-quality publication that helps bring our membership together.

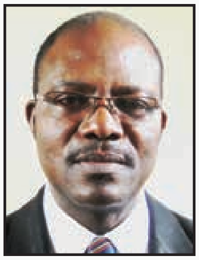
This past year also saw a good number of CNS members receiving awards at the CNS/CNA Honours and Awards ceremony held in conjunction with the annual conference. It is gratifying to see members of our Society recognizing the efforts and contributions of their peers in this great industry of ours.

In closing, I would like to note the fine work of our Council, Executive, and all of our volunteers over the past year, and would like to recognize the nuclear companies that support their employees to work on CNS activities and programs. It is through our volunteers' efforts that we remain an active and vigorous Society. The programs they help deliver provide important services to our industry in ensuring the sharing of important technical information and experience through our conferences and courses. I also wish to congratulate incoming CNS President Peter Ozemoyah and the new Council and wish them all the best, and offer to them my continuing support throughout the coming year. I know it will also be another great year!

Paul D Thompson
President
Canadian Nuclear Society

Address by incoming President – Peter Ozemoyah

At the Canadian Nuclear Society (CNS) Annual General Meeting (AGM), June 19, 2016



Good afternoon, Ladies and Gentlemen, Happy Fathers' Day to all those celebrating.

I am humbled to stand before you this afternoon to address you as the President of this great organization – an organization which according to Dr. John Barret is "Repository of Great Experience and Knowledge about all things Nuclear".

My predecessors have left me big shoes to fill, a task that I know will be very difficult to accomplish. Luckily, I still have most of my predecessors around who will ensure that whatever mistakes I make in trying to fill the shoes, will be few with minimal adverse effect to the Society. As I accept this position, I thank you ladies and gentlemen, for putting your trust in me. Past President Frank Doyle once asked all of us in CNS to reflect on what we can do to help the Society help our members achieve continuing success in the future of Nuclear. I am echoing this request today as I accept this position.

CNS Strategic Plan and the Changing Nuclear Industry Landscape

No organization does well without a plan and in particular, a strategic plan. Jacques Plourde and his team have been working on a new Strategic Plan for the Society. We look forward to the completion of this Plan which will take us into a new future.

The changes that have been taking place in various Nuclear-related establishments in the Country in the past few years are noticeable. We know that the CNS will have to adapt to this changing nuclear industry landscape. To be abreast with these changes and still keep good rapport with the concerned establishments, Paul Thompson and his Executive started the "Relationship Meetings" between CNS and Major Stakeholders. The CNS Executive has started to see some positive results from these meetings. The new Executive will continue this initiative which is aligned with the Strategic Plan being developed by Jacques and his team.

The Branches

Our Branches are very important to the future of this Society. In Paul Thompson's earlier remark, he said that "Branch activity is the grass roots of our Society". This statement is very true. For this reason and as a source of encouragement to the Branches, I intend to visit all of them during my year in office starting with those not visited by Paul during his year. I believe the combination of these Branch visits and the Relationship Meetings with major stakeholders will inject new life into our Society.

The Year Ahead

The main objective of CNS is information dissemination as it relates to the nuclear industries. I will therefore support any outreach and/or public information efforts of the Council that will help increase membership.

Many of our activities are directed towards the same group and industries. This limits our ability to attract new members and increase our financial base. I will therefore work with the Executive and the Council to:

- Infuse new energy and diversity to CNS activities to make it more attractive and increase value to members.
- Review the current membership structure with a view to creating opportunities that encourage most Nuclear Science and Tech Professionals to become members.
- Increase membership
- Implement the current Strategic Plan of the Society spearheaded by Jacques Plourde .
- Encourage participation of all CNS constituent units (Divisions, Committees, and Branches) in the said Strategic Plan.
- Encourage the creation of specific and achievable goals by all constituent units, and develop actualization metrics for these goals.
- Adhere to the directives of Council towards fiscal responsibility and sustainability.
- Strengthen relationships with various levels of Government and their representatives.

Conclusion

To achieve these goals, I will rely on Herbert J. Taylor's 24 Words titled ***"The 4 Way Test"*** *of the Things We Think, Say or Do:*

1. Is it the Truth?
2. Is it Fair to All Concerned?
3. Will it Build Goodwill and Better Friendship?
4. Will it be Beneficial to All Concerned?

I look forward to working with the new Council. Together, I am confident we will achieve our goals.

Thank you all; Help keep the CNS Light Shining Bright.

News from Branches

BRUCE Branch

The Bruce Branch sponsored two CNS student prizes at the recently held Bluewater District Regional Science and Technology Fairs. The two student winners were also selected to move on to the Canadian Science Fair.

We have also confirmed and scheduled a branch dinner meeting and presentation with the **CNS President Paul Thompson** on **May 16th**.

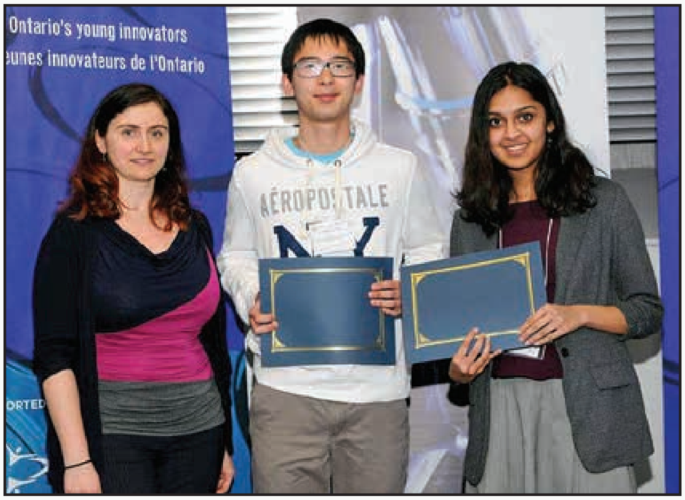
CHALK RIVER Branch

The Renfrew County Science Fair was held **April 9th** and was a great success. CNS Chalk River Branch members were on hand to witness the many projects by aspiring young scientists and engineers. The branch also proudly awarded the CNS Nuclear Research Award of Excellence to the following 3 projects:

- "Imagery of Dense Material with Cosmic Ray Muon Scattering" by Deyang Li and Shruthi Sailesh (Mackenzie Community School)
- "Harnessing Waste Heat from Spent Nuclear Fuel" by Ryan Broome and Bradley Welna (St. Mary's)
- "Wattage Wheel" by Samuel Abbott and Lee Whorley (Pine View)

These projects demonstrate a new generation of nuclear scientists, technicians and technologists waiting to emerge and further our industry! The fair also included several interactive activities for the students run by **CNS Communications Director, Jeremy Whitlock**.

Upcoming events for the CNS Chalk River Branch include the **Renfrew County Science Olympics (May 20th)** and future talks planned for the summer months.



CNS CRB member Ruxandra Dranga presents the CNS Nuclear Research Award to Deyang Li and Shruthi Sailesh for their project, "Imagery of Dense Material with Cosmic Ray Muon Scattering".

CNS CRB member Ruxandra Dranga presents the CNS Nuclear Research Award to Samuel Abbot and Lee Whorley for their project, "Wattage Wheel".

CNS CRB member Ruxandra Dranga presents the CNS Nuclear Research Award to Ryan Broome and Bradley Welna (not pictured) for their project, "Harnessing Waste Heat from Spent Nuclear Fuel".

GOLDEN HORSESHOE Branch (GHB)

On March 31st Jason Sharpe and David Joyal from the GHS branch participated in judging the annual Bay Area Science and Engineering Fair (BASEF).

The fair was filled with over 550 students from grades 7-12. $400 dollars in prizes was given to four students demonstrating excellence in their research projects that were based on nuclear science and energy research. Pictures of the awards ceremony can be found at: **www.cns-snc.ca/cns/page-1455720080.58/**

NEW BRUNSWICK Branch

In our efforts to bring high quality lectures and activities of interest to the NB Branch membership, a call to reconstitute a formal branch executive committee was issued. The branch has been fortunate in attracting new and experienced talent in helping to guide branch activities and we extend our appreciation for their involvement. Your current branch representatives are:

Chair:	**Derek Mullin**
Past Chair:	**Mark McIntyre**
Secretary:	**Rick Sancton**
Treasurer:	**Elif Can Usalp**
Member-at-Large:	**Paul D. Thompson**
Member-at-Large:	**Vacant**

If you are a member in good standing and have any interest in playing a more active role in the NB Branch activities in promoting the nuclear industry through outreach and education, or with providing assistance with planning and carrying out branch activities, please contact the Chair, Derek Mullin, at dmullin@nbpower.com.

The New Brunswick Branch Website is up and running at https://www.cns-snc.ca/CNS/new-brunswick/. Be sure to visit the website for all of the latest branch news and activities. In addition, the New Brunswick branch has also created a Facebook group at https://www.facebook.com/groups/1607633602808189/ to further our efforts to keep branch members including those interested in Canadian nuclear science and engineering, direction and advancements in the Canadian nuclear industry, and nuclear operations of the Point Lepreau Nuclear Generating Station.

SHERIDAN PARK Branch

The executive meeting of CNS Sheridan Park branch was held on April 15 to discuss the branch activities and to add new members in the executive committee. The following is updated list of members of the CNS SP Branch executive committee:

Chair:	**Raj Jain**
Vice Chair:	**Hazen Fan**
Secretary:	**Peter Schwanke**
Treasurer:	**Vikram Sharma**
Communication Coordinator:	**Raj Jaitly**
Program Coordinator:	**Fabricia Pineiro**

Peter Schwanke participated at the **Peel Region Science Fair 2016** as special judge on **April 16-17**. The following five projects were awarded the special CNS award.

1. "The Thermo Voltaic Cell " - Karthik Prasad and Abhinav Boyed
   School: Glenforest Sec. School
2. "Increasing S.I. Efficiency through Novel Chamber Geometry" - Keaton Chadwick
   School: Chinguacousy Sec. School
3. "Why Thorium is the best alternative energy?" - Aryan Gajelli
   School: The Valleys Senior Public School
4. "Dual Axis Solar Tracker" - Rahul Gudise
   School: W. G. Davis Senior Public School
5. "Harnessing Energy From Traffic Using Piezoelectric Crystals" - Saharsh Hariharan
   School: The Woodlands School

CNS Sheridan Park Branch is planning to organize a tour to McMaster Nuclear Reactor (MNR) and McMaster Manufacturing Research Institute (MMRI) on **June 08, 2016.**

TORONTO Branch

Eric Jelinski and Andrew Ali from the CNS Toronto Branch took part in the **University of Toronto Energy Fair on Tuesday, April 5th**. They had posters and other promotional material displaying the benefits of nuclear energy.

Terrestrial Energy was also present and had a table with their reactor concept, integral molten salt reactor. It was a great opportunity to engage with students, professors and other industry professionals to talk about the nuclear industry and CNS.

UOIT Branch – Cristina Mazza

A tour of the **Mechatronics and Robotic Systems lab at UOIT** was hosted to introduce students to robotics projects designed for use in the nuclear industry, especially Cameco. This event had a good turnout from students from a wide variety of engineering disciplines.

Branch members volunteered at the **2016 Science Rendezvous at UOIT**, to teach young minds about radiation through the Radioactive Balloon Demonstration. The CNS display had a great response from both parents and children.

Upcoming events being planned for the summer:

- **McMaster Nuclear Research Reactor tour**
- **General Electric or Cameco tour**

WESTERN Branch

General

The Branch has begun to organize 'chapter' events for members in communities that are within the branch's region. To date chapter events have taken place in Calgary with plans to hold chapter events at the University of Saskatchewan and University of Regina starting this fall.

Branch Activities

Jason Donev organized a chapter meeting of the Branch at the University of Calgary on **16 March**, featuring a presentation by the Alberta Energy Regulator on its role. Sixteen people attended.

Outreach Activities

Duane Pendergast, **Shaun Ward** and **Laurence Hoye** were part of a delegation from the Energy Collegium in Lethbridge that presented to Southern Alberta Mayors and Reeves Committee meeting on **May 6**. The presentation, which was invited as the result of their presentation to the Southern Alberta Municipalities Association in January, emphasized the potential role for nuclear and hydro in the province's clean energy strategy.

Neil Alexander presented two talks in Regina. The first on **16 March** was a public lecture presented by the Johnson Shoyama Graduate School of Public Policy. It was followed a week later with a talk at the University of Regina Faculty of Science's science pub series on **March 24.**

David Malcolm and **Neil Alexander** are also participating in Canadian Nuclear Laboratory's Advanced Reactor Forum **May 10 and 11**.

CNSC invites comments on draft REGDOC-1.1.3, Licence Application Guide: Licence to Operate a Nuclear Power Plant

May 31, 2016 – Ottawa, ON

The Canadian Nuclear Safety Commission (CNSC) is consulting the public on draft regulatory document REGDOC1.1.3, *Licence Application Guide: Licence to Operate a Nuclear Power Plant*. Please submit your feedback by July 30, 2016. To review and comment on the document, visit the REGDOC-1.1.3 Web page.

This draft provides regulatory requirements and expectations for submitting an application to the CNSC to obtain or renew a licence to operate a nuclear power plant in Canada.

Comments submitted, including names and affiliations, will be made public.

The CNSC regulates the use of nuclear energy and materials to protect the health, safety and security of Canadians and the environment; to implement Canada's international commitments on the peaceful use of nuclear energy; and to disseminate objective scientific, technical and regulatory information to the public.

Quick facts

- REGDOC-1.1.3 will be used to assess licence applications for proposed new reactor facilities and for licence renewals for existing reactor facilities.
- Each licence application undergoes a rigorous technical review before being considered by the Commission. The process includes transparent public hearings.
- Nuclear power plants have been producing electricity commercially in Canada since the early 1960s. Today, 5 plants in 3 provinces house 22 nuclear power reactors. Nuclear energy produces about 15 percent of Canada's electricity.
- The CNSC welcomes feedback at any time on regulatory documents.

IAEA Publications

The IAEA is pleased to announce the publication of:

Safety of Nuclear Power Plants: Commissioning and Operation
IAEA Safety Standards Series No. SSR-2/2 (Rev. 1)

This publication describes the requirements to be met to ensure the safe operation of nuclear power plants. It takes into account developments in areas such as long term operation of nuclear power plants, plant ageing, periodic safety review, probabilistic safety analysis and risk informed decision making processes. In addition, the requirements are governed by, and must apply, the safety objective and safety principles that are established in the IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles. A review of Safety Requirements publications was commenced in 2011 following the accident in the Fukushima Daiichi nuclear power plant in Japan. The review revealed no significant areas of weakness and resulted in just a small set of amendments to strengthen the requirements and facilitate their implementation, which are contained in the present publication.

STI/PUB/1716, 47 pp.; 2 figs.; 2016; ISBN: 978-92-0-109415-5, English, 48.00 Euro

Electronic version can be found:

www-pub.iaea.org/books/IAEABooks/10886/Safety-of-Nuclear-Power-Plants-Commissioning-and-Operation

Cyclotron Produced Radionuclides: Emerging Positron Emitters for Medical Applications: 64Cu and 124I
IAEA Radioisotopes and Radiopharmaceuticals Reports No. 1

The growing number of medical cyclotrons and positron emission tomography/computed tomography (PET/CT) centres as well as the proven high clinical utility of fluorodeoxyglucose (FDG) in cancer patients has led to interest in possibilities for the use of PET tracers which are in different stages of clinical evaluation. This publication presents the outcome of an IAEA coordinated research project on this topic and provides a comprehensive overview of the technologies involved in the production of copper-64 and iodine-124, techniques on preparation of targets, irradiation of targets under high beam currents, target processing, target recovery and labelling. It provides guidance to enhance copper-64 and iodine-124 production and applications. This book will appeal to scientists and technologists involved in putting cyclotron based radioisotope production into practice, as well as postgraduate students in the field.

STI/ PUB/1717, 63 pp.; 38 figs.; 2016; ISBN: 978-92-0-109615-9, English, 38.00 Euro

Electronic version can be found:

www-pub.iaea.org/books/IAEABooks/10791/Cyclotron-Produced-Radionuclides-Emerging-Positron-Emitters-for-Medical-Applications-64Cu-and-124I

Knowledge Management and Its Implementation in Nuclear Organizations
IAEA Nuclear Energy Series No. NG-T-6.10

The IAEA's nuclear knowledge management activities provide guidance in knowledge management and assist in transferring and preserving knowledge, exchanging information, establishing and supporting cooperative networks and in training the next generation of nuclear experts. This publication shares best practices and experiences based on the knowledge management assist visit programme undertaken by IAEA expert teams during the period 2005-2013. These visits have involved different types of organizations, including NPPs, nuclear R&D organizations and nuclear based educational establishments such as universities. Based on the records of these visits, a secondary aim of this publication is to provide feedback and recommendations for future development of the assessment tool(s) and participating organizations for improving future assist visits.

STI/PUB/1724, 52 pp., 4 figs.; 2016; ISBN: 978-92-0-107215-3, English, 31.00 Euro

Electronic version can be found:

www-pub.iaea.org/books/IAEABooks/10849/Knowledge-Management-and-Its-Implementation-in-Nuclear-Organizations

2015-2016 CNS Council • Conseil de la SNC

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CNS WEB Page - Site internet de la SNC

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

http://www.cns-snc.ca

2016

July 31-Aug. 3 **ANS International Meeting on Decommission & Remote Systems**
Pittsburgh, PA, USA
cns-snc@on.aibn.com

August 15-18 **13th International Conference on CANDU Fuel**
Holiday Inn Waterfront Hotel
Kingston, Ontario
cns-snc@on.aibn.com

Sept. 11-14 **3rd Canadian Conference on Nuclear Waste Management, Decommissioning and Environmental Restoration**
Marriott Hotel
Ottawa, ON
cns-snc@on.aibn.com

October 9-13 **NUTHOS-11**
Gyeongju, South Korea
cns-snc@on.aibn.com

2017

May **CANDU Maintenance and Nuclear Component Conference (CMNCC-2017)**
Toronto, Ontario
cns-snc@on.aibn.com

June 4-7 **37th CNS Annual Conference & 41st CNS/CNA Student Conference**
Niagara Falls, ON
cns-snc@on.aibn.com

July 31-Aug. 4 **13th International Topical Meeting on Nuclear Applications of Accelerators (AccAPP17)**
Quebec City, QC
cns-snc@on.aibn.com

Sept. 24-27 **2nd International Meeting on Fire Safety and Emergency Preparedness for the Nuclear Industry (FSEP 2017)**
Toronto, ON
cns-snc@on.aibn.com

Canadian Nuclear Safety Commission invites comments on draft REGDOC-3.1.2, Reporting Requirements for Non-Power Reactor Class I Nuclear Facilities and Uranium Mines and Mills

July 11, 2016 – Ottawa

The Canadian Nuclear Safety Commission (CNSC) is asking the public to provide comments on draft REGDOC3.1.2, *Reporting Requirements for NonPower Reactor Class I Nuclear Facilities and Uranium Mines and Mills*.

Also included is a request for information (RFI) on the proposed implementation of REGDOC3.1.2, which provides additional information on the potential impacts and implementation of this regulatory document.

To review and comment on the regulatory document and the RFI, visit the REGDOC3.1.2 webpage. Please submit your feedback by September 9, 2016. Comments submitted, including names and affiliations, will be made public.

This draft sets out requirements and guidance for reports and notifications that licensees of Class I nuclear facilities (excluding power reactors) and of uranium mines and mills must submit to the CNSC. This document presents the types of reports, their frequency and the applicable timeframe for reporting.

The CNSC regulates the use of nuclear energy and materials to protect the health, safety and security of Canadians and the environment; to implement Canada's international commitments on the peaceful use of nuclear energy; and to disseminate objective scientific, technical and regulatory information to the public.

Quick facts

- This regulatory document incorporates and clarifies reporting requirements in the Nuclear Safety and Control Act and the regulations made under it.
- The CNSC welcomes feedback on regulatory documents at any time.

Love and Nuclear Will Keep Us Together

by JEREMY WHITLOCK

Why hello Nuclear Power, please come in. It's been a while – what brings you to my office today?

I'm ... not sure Doc. Everything's going reasonably well, I suppose, but...

Yes indeed, I've heard good things - $25 billion to be invested in Ontario refurbishments over the next two decades, Pickering extended to 2024, SMR vendors popping up like mushrooms, Chalk River's future finally sorted out...

Yeah that's all great.

So tell me, what's troubling you?

Well, it's just that the world's falling apart.

Excuse me?

Britain's disintegrating, the EU's a mess, Russia's annexing, the U.S. is insane... It seems like even though we had two World Wars that proved the dangers of imperialism and nationalism, the whole world is slipping back again. It's like three generations later we're morons again.

I see... Well, this may all be true, I suppose, but what really does it have to do with you?

I was supposed to be part of the new wave, Doc. Equalization, global human rights, liberalized economies.

You?

Energy! When people aren't fighting over energy, everything else is small potatoes. I was the way – universal access to energy. Distribution of wealth. Universal prosperity.

Okay, well, that does sound grand, but perhaps a tad unrealistic? You certainly have the potential for universal access, but maybe it all depends more on good old human nature and politics, which aren't necessarily ... shall we say, inherently egalitarian...?

Aren't you supposed to be cheering me up?

Hm, well, not exactly; I'm supposed to help you understand yourself.

Well I think I'm beginning to understand that maybe the opposite has happened out there – that abundant energy has shifted focus from survival to protectionism. People have had time to build walls. When you know where your food is coming from for the foreseeable future, you start looking around and finding problems with the folks around you.

Or the folks coming across your borders?

Exactly! You know, maybe we need a good war.

Well, it's been a while I suppose.

Exactly!

I'm kidding. Look, don't you think you're already doing the best you can do? Maybe others should be stepping up? Surely the maintenance of sustainable energy supply is a worthy enough contribution?

I.. I want to do more.

Okay... well, you're the most abundant, cost-effective, cleanest, safest, most universally available, long-term sustainable energy source on the planet. What more do you want to do exactly?

I don't know - maybe if I were smaller... cheaper... safer. What good is being all those things you say, when in the end I'm seen as just another corporate industrial elitist enabler of centralized control?

And being smaller, cheaper, safer will change that?

Well if it takes three generations for people to forget how nationalism can tear a planet apart, maybe this will take that long to come around too – but look, I can open up the north, I can make Inuit communities self-sufficient on energy, I can enable economic growth where, literally, nothing grows.

Cute.

I can make Saskatchewan master of its own energy supply, I can make coal a thing of the past from coast to coast, I can make electric cars truly green, I can enable expansion of renewable supply without decreasing grid reliability, I can drive industrial growth – I can make Ontario great again!

Oh is that so?

Sorry, couldn't resist. But there's so much I could be doing, if people let me. I could be the cornerstone of Trudeau's "shared prosperity", "embracing diversity", "positive leadership" – I can make all that sunny ways stuff happen.

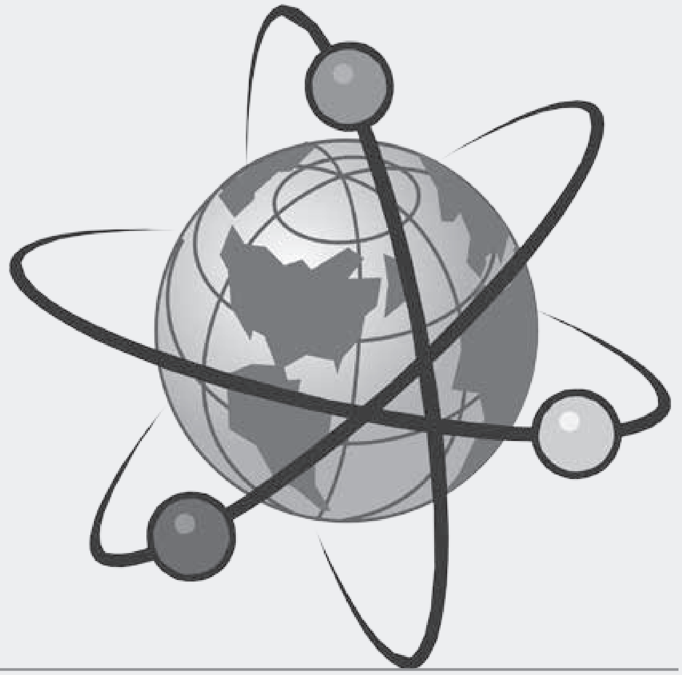
So you want to be a superhero? Save the world?

Yes! Why not – I've heard that radiation helps with that too.

And it doesn't bother you that your own government has basically abdicated its national nuclear program? That it has no energy strategy for the north? That it's walking away from the global nuclear medicine infrastructure it helped to invent? That students in the future won't be able to visit the historic nuclear reactors that made us world leaders? That soon we won't have a national neutron source and yet we still call ourselves a Tier 1 nuclear nation like we have no idea what that means?

You've just described my Gotham. Say, I could use a sidekick.

Sign me up. We've got work to do.



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Depending on your requirements, we may work with or through trusted nuclear suppliers to deliver the best solution to you. In these cases, we will consult with and advise you on the most appropriate path forward.

For more information, please contact us at ***commercial@cnl.ca*** or visit us at ***cnl.ca/commercial***.