CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

JUNE 2015 JUIN VOL. 36, NO.2

- Annual Conference in Saint John
- Nuclear Achievement Awards
- Fire Safety and Emergency Preparedness - First International Meeting
- Sustainable Uranium Energy

New Operator for Canada's Nuclear Laboratories

The much anticipated announcement of the restructuring of Atomic Energy of Canada Limited (AECL) to a Government Owned Company Operated (GoCo) facility was made by Canada's Minister of Natural Resources, the Honourable Greg Rickford, on June 26, 2015. There were bids from several organizations and the Government has selected the Canadian National Energy Alliance (CNEA) to manage and operate Canadian Nuclear Laboratories (CNL), a subsidiary of AECL.

The CNEA was formed from a combination of companies including CH2M HILL, EnergySolutions, Fluor, SNC-Lavalin Group Inc, and Rolls-Royce. According to the CNEA web site, "the procurement addresses three key objectives for the Government of Canada including: managing Canada's radioactive waste and decommissioning responsibilities at the Chalk River and Whiteshell Laboratories; ensuring that Canada's world-class nuclear science and technology capabilities and knowledge continue to support the federal government in its nuclear roles and responsibilities; and providing industry access to nuclear science and technology expertise at the Nuclear Laboratories. CNEA was formed to safely transform the Canadian Nuclear Laboratories and secure Canada's role in the global nuclear marketplace."

How will GoCo impact Canadian Nuclear Laboratories? How will it impact on the nuclear industry? And how will this impact Canadians?

The impact on CNL is likely to be very positive. During your career you probably attended more than one team-building exercise on the quality of decisions. In my case we looked at a survival scenario. A small group of ski enthusiasts are lifted by helicopter to a remote cabin on a snowy mountain. There is a sudden blizzard, the helicopter crashes, the radio is broken and the pilot is dead. The others survive the crash, but in order to survive the blizzard and find shelter they need to rank by priority any equipment they can salvage and carry from the crash. Each participant submits their individual rankings. Then they work as a team, convincing each other as to the rankings. The facilitator has rankings prepared by a professional survivalist. The list submitted by the team compares well with the professional's list, whereas no one individual comes close. The quality of a team decision is better than that of an individual. CNL now has a team of five companies with their collective expertise and experience forming the new alliance. Hence, the positive outlook for CNL.

Organizational restructuring is bound to have some hiccups is the beginning. For sure the formation Candu Energy had its first hiccup early on - a prolonged and bitter labour strike. However they have since made significant gains in China, Romania and the UK. By any measure they are doing quite well and no doubt so will CNL.

The industry is driven by the needs of nuclear utilities. The Ontario Government is committed to life extension of ten CANDU reactors over the next ten years. Utilities elsewhere are also extending the life of their existing CANDUs and some will be building new CANDUs such as in the UK. Companies in Ontario are selling components and services world-wide; not just for CANDU customers but for other reactor types as well. This is a good time to get into the industry if you want a career for life - check out the Careers page on any Canadian nuclear company. CNL has dozens of vacancies for engineers, scientists and supporting roles such as finance and project management.

Canadians will benefit in many ways. Taxpayers no longer have the burden of subsidizing ventures such as AECL's Advanced CANDU, which did not have a customer. Other than management of legacy waste, taxpayers will no longer be subsidizing R&D. And revenues from overseas sales and services will help not only Canadian nuclear companies but all Canadians in general.

Jolly good, CNL and CNEA!

In This Issue

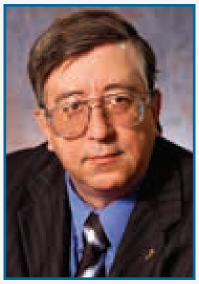
The highly successful CNS Annual Conference is our lead item. For the first time it included the Organization of Canadian Nuclear Industries (OCI) and every exhibit booth was booked. Also for the first time was the Technical Meeting of the Fire Safety and Emergency Response for the Nuclear Industry, also included in this issue.

As is traditional at the Annual Conference there was the Honours and Awards presentations for outstanding contributions, summarized by Honours and Awards Chair Ruxandra Dranga.

The issue of climate change is heating up. During the International Congress on Advances on nuclear Power Plants in Nice, France, 39 nuclear societies including the CNS signed a declaration that presents their commitment to the fight against climate change. Dan Meneley presented a paper called "Sustainable Uranium Energy - an Optional Future" (included in this issue). Will we run out of oil and gas, or just decide to leave it in the ground? No problem. Uranium can produce everything from electricity to gasoline.

As usual we have a selection of technical papers, news (including our General Meeting) and last but never least Endpoint with Jeremy Whitlock`s whit in the form of a pie ...

From The Publisher



It's a claim heard all the time, that the nuclear industry is in decline, that the technology is somehow outdated.

There was little evidence of any of this at the Canadian Nuclear Society (CNS) Annual Conference in Saint John, New Brunswick this year. By any reasonable standard, the conference was a roaring success. More than 400 delegates were in attendance, the conference was one of the best-sponsored CNS annual conferences in years, and all available space for exhibitors was fully booked.

New products and technology were on display or being presented throughout the conference. Like PBNC in 2014, the conference served as a showcase of all the directions in which our industry, science and technology is moving forward.

But science and technology were not the only places where strong progress was in evidence. For the first time, the CNS co-operated with a number of other organizations in staging this year's annual conference. Held jointly with it was a Suppliers Day organized with the Organization of Canadian Nuclear Industries (OCI). By combining forces and events, the CNS and OCI were able to attract a much larger audience than would otherwise have been the case had they been held separately.

Also of great importance was the strong participation of the Nuclear Waste Management Organization (NWMO). They sponsored a strong contingent of municipal leaders from across northern Canada to attend the conference and become familiar with the industry and its members.

It's no accident how a highly successful conference like this happens. Success starts with a strong organizing committee. The conference also benefited from a very high level of support from the local utility NB Power.

The organizing committee also looked at new methods to be used in holding CNS conferences. Thus, there was for the first time a joint venture with OCI. Professional services were used to secure sponsorship for essentially all available promotion opportunities at the conference. The CNS may indeed be a volunteer society, but that doesn't prevent it from using expert services for specific tasks in things like sales and marketing. And as this year's conference demonstrated, such can be very effective.

The Annual Conference was followed just two weeks later by the 1st International Technical Meeting on Fire Safety and Emergency Preparedness (FSEP). This conference was the inspiration of the CNS Program Committee Chair Tracy Lapping. Stretching out over more than two days, this first of a kind conference for the CNS attracted more than 100 delegates and a strong group of exhibitors and sponsors. A huge topic area, FSEP introduced the CNS to an entirely new group of companies, individuals and subjects of interest. Its success guaranteed that this will indeed be only the first FSEP; it will be offered again in 2017.

The key to all of the above is innovation: innovation in topic areas, and innovation in methods, execution and cooperation. These two events show that there is indeed a bright future for the CNS, one of growth and new areas for our Society to explore.

Also at this year's Annual Conference was the Annual General Meeting of the CNS. This year, a record 11 new Council Members were elected. What this shows is that the CNS can indeed attract volunteers from within Canada's nuclear energy professionals with a variety of backgrounds and expertise.

All of this is taking place in a national context of growth and renewal of our industry. NB Power's Point Lepreau returned to service last year. Ontario' nuclear utilities are about to launch a comprehensive program of refurbishment of 10 reactors over the next decade, promising billions of dollars and millions of man-hours of work for Canada's nuclear industry. For the first time since the early 1990s, nearly two-thirds of Ontario's electricity, Canada's industrial heartland, comes from nuclear power.

One of the most famous last lines ever delivered in a movie by Paul Newman many years ago clearly applies for us today.

"I'm back!"

C.G.H.

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~ Cover Photo ~

Aerial view of the Bruce Nuclear Generating Complex near Kincardine, Ontario

Photo courtesy of Bruce Power

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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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CNS Annual Conference in Saint John a Great Success

by COLIN HUNT

The Canadian Nuclear Society (CNS) held its 35th Annual Conference in Saint John, NB on May 31-June 3, 2015, combined with the 39th Annual CNS/CNA Student Conference. Despite the wet weather, this year's annual conference must be reckoned one of the most successful in years.

More than 425 delegates, exhibitors and students were in attendance for the conference. Contributing strongly to the success of the conference was the attraction of a number of other events taking place within the conference. For the first time in the history of either organization, the CNS combined with the Organization of Canadian Nuclear Industries (OCI) to hold an OCI Suppliers Day at the Saint John conference.

A Suppliers Day is a regular schedule of events whereby OCI hosts its member companies at the location convenient to a local nuclear power station. These provide opportunities for station staff to meet with companies and view their products and services. For Saint John, combining with the CNS meant that every exhibit booth available was taken with more than 40 exhibitors present throughout the conference. By combining the conference and the Suppliers Day, several Point Lepreau staff were able to attend.

This conference marked another new collaboration with the Nuclear Waste Management Organization (NWMO). The NWMO has been engaged for a number of years in public outreach throughout parts of northern Canada, in particular Ontario, presenting information regarding the future possibility of community hosting of a geologic repository for used nuclear fuel. To that end, the NWMO invited the attendance at the conference of a number of municipal officials and aboriginal leaders to meet with members of the nuclear industry and to attend information and technical sessions. The NWMO also brought its display trailer to the conference, showing a full sized version of its proposed transport cask for used nuclear fuel.

There were two other special events taking place at the conference. The CNS hosted a meeting of the N-6 group, which is a regular gathering of the heads of the various nuclear associations and societies in Canada interested in communications and public outreach. It includes the CNS, CNA, OCI, Women in Nuclear Canada (WiN), UNENE, the North American Branch of the Young Generation Nuclear (NAYGN),

The conference begins – filling the bags.

Conference organizing committee.

*Gaetan Thomas,
NB Power President.*

*Pierre Tremblay,
Harold A. Smith Lecture.*

and the Canadian Nuclear Workers Council (CNWC).

Of interest to the large number of non-industry members, the CNS hosted a special three-hour seminar on Monday, June 1, "Nuclear For Everyone", presented by Dr. Jeremy Whitlock. Organized in co-operation with the NWMO were two special morning plenary sessions on June 2 and 3 devoted to waste management and decommissioning.

The conference commenced on Monday with two strong plenary sessions on utility collaboration to improve CANDU reactor performance. After opening remarks by CNS President Jacques Plourde and Honorary Conference Chair Gaetan Thomas, President and CEO of NB Power, presentations were made by all Canadian nuclear power utilities, Bruce Power, NB Power and Ontario Power Generation (OPG). This session included presentations from Fred Dermarkar of the CANDU Owners Group (COG), and Hong Tan, Plant Manager of Qinshan Phase 3.

One of the important highlights of the conference was the Harold A. Smith Lecture given by Pierre Tremblay of Canadian Nuclear Partners. It is now the practice of the CNS to hold this lecture and the long-standing WB Lewis Lecture in alternate years. The former is devoted to topics of operational interest, while the Lewis Lecture is devoted to matters of scientific interest.

Also on Monday was the Student Poster Session.

Principal features of the conference on Tuesday were the Honours and Awards Luncheon and during the evening the Conference Banquet. In the case of the H&A Awards Program, it was widely recognized that this was the first in a number of years in which there were recipients for all of the various awards. The banquet was followed by entertainment which continued for most of the evening. Details of the awards program are found elsewhere in this edition of the Bulletin.

Also of general interest on Tuesday were the panel discussion on international developments in repositories, and two plenary sessions on managing risk, and vendor roles in a changing industry. The last two sessions were chaired respectively by Joy Shikaze, Executive Director of WiN, and Ron Oberth, President of OCI.

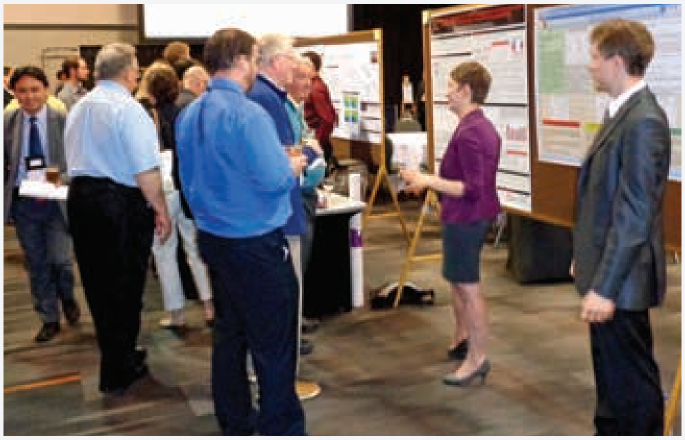
Wednesday contained a number of interesting features. These included plenary sessions on waste management chaired by David Legault of Worley Parsons, nuclear research and development chaired by Robert Walker of CNL, and a panel discussion on the transport of used nuclear fuel.

All three days of the conference also contained parallel technical sessions each afternoon. In total, between the main conference and the student conference, more than 100 technical papers were presented during the three days of the conference.

Also taking place on Sunday, May 31 was the Annual General Meeting of the CNS, details for which are found elsewhere in this edition of the Bulletin.

Hong Tan, TWNPP.

Fred Dermarkar, COG.



Student Poster Session.

It's New Brunswick so it must be lobster.

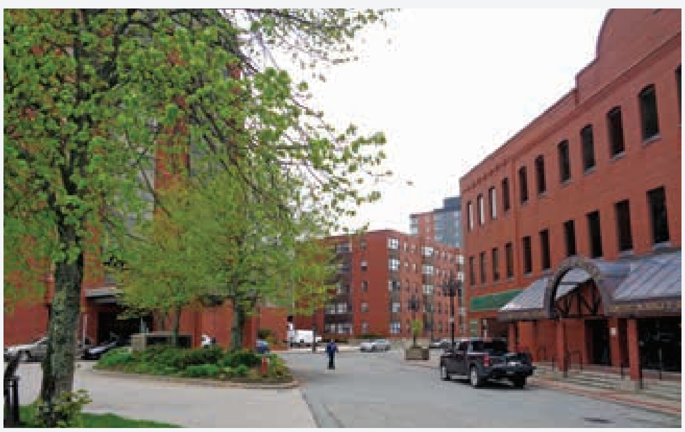
NWMO demonstration trailer.

The conference was made possible by a large number of sponsors. These included the Host Sponsor NB Power and Main Sponsor NWMO. Other Sponsors included Black & McDonald, Bruce Power, the CNA, Canadian Nuclear Laboratories (CNL), Canadian Nuclear Partners, Canadian Nuclear Revitalization Partners, Canadian Nuclear Safety Commission (CNSC), Canadian Institute for Non-Destructive Testing (CINDE), GE-Hitachi, Hitachi, The Ian Martin Group, Innovation Canada Alliance, Kinectrics, Nordion, Ontario Power Generation (OPG), Power Workers Union (PWU), SNC-Lavalin, Stern Laboratories, Tetra Tech, and Westinghouse.

The conference was the result of the hard work of the conference organizing committee. This included the Honorary Chair Gaetan Thomas represented by Kathleen Duguay, General Conference Chair Jacques Plourde, Conference Organizer Ben Rouben, Technical Program and H&A Chair Ruxandra Dranga, Peter Ozemoyah and Keith Scott Plenary Program Co-Chairs, Sponsorship and Exhibits Chair Kris Mohan, Communication Chair Jeremy Whitlock, Student Conference Co-Chairs Tracy Lapping and William Cook, Conference Treasurer Mohinder Grover, and Guest Seating Chair John Roberts.

NWMO used fuel shipping cask.

Left to right: Fred Dermarkar, COG; Ramzi Jamal, CNSC; Paul Thompson, CNS President.



Saint John Market Square. Hotel on left, Conference Centre on right

Saint John Harbour.

Poster winners Hongbing Yu, Dylan Pierce, Kendall Boniface with William Cook, Tracy Lapping, Jacques Plourde.

2015 Canadian Nuclear Achievement Awards

by RUXANDRA DRANGA, CNS-CNA Honours and Awards Chair

H&A Chair Ruxandra Dranga opens the Awards Ceremony.

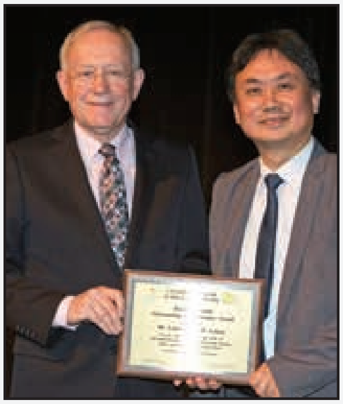
On June 2, 2015, the CNS and CNA jointly recognized 11 recipients for their outstanding contributions within the Canadian Nuclear industry and the Canadian nuclear research and academic communities, during the 2015 Canadian Nuclear Achievement Awards. The awards ceremony was held in Saint John, New Brunswick, during the Canadian Nuclear Society (CNS) Annual Conference. This year, awards were presented for eight out of the nine available award categories, to recipients which demonstrate the large array of knowledge, expertise and educational and outreach activities performed by our remarkable colleagues.

Dr. Robert S. Walker receives the Ian McRae award from CNA President, John Barrett.

The **Ian McRae Award of Merit** was presented to **Dr. Robert S. Walker**, President and CEO of Canadian Nuclear Laboratories(CNL), for inspirational leadership in the transformation of Canadian Nuclear Laboratories, and the establishment of the Canadian Nuclear Leadership Forum (NLF). Dr. Walker was the driving force behind the creation of the NLF, a strategic initiative to unite the nuclear industry in a common purpose, and launch its first-ever, long-term Vision and Action Plan, focused on Excellence, Competitiveness and Leadership. During the same period of time, he was also leading the journey to transform CNL, from the R&D arm of a Crown Corporation, to a stand-alone, high-performing national nuclear laboratory.

Two **Harold A. Smith Outstanding Contribution Awards** were presented this year. The first award was presented to **Dr. Jin Jiang**, Professor at Western University, for advancing the state-of-the-art in instrumentation and control for nuclear power plants in Canada and internationally. Dr. Jiang has made exceptional contributions to the nuclear community in Canada, and has become an internationally distinguished authority and researcher in the area of instrumentation and control systems. He is a leader in this field and was instrumental in maintaining Canada's leadership position in advanced nuclear Instrumentation and Control research, development and education.

Dr. Jin Jiang receives the Harold A. Smith award from CNA President, John Barrett.



Dr. Laurence Leung receives the Harold A. Smith award from CNA President, John Barrett.

The second award was presented to **Dr. Laurence K. H. Leung**, Manager of Advanced Concepts and Collaborations at Canadian Nuclear Laboratories, for his contributions in the field of thermalhydraulics, and for advancing nuclear safety and international cooperation. Dr. Leung has made substantial contributions in the field of thermalhydraulics to advance nuclear reactor design, and in particular the CANDU reactor design. Throughout his career, Dr. Leung has been an enthusiastic leader in his field, not only in the technical areas, but also through his personal drive and energy to promote collaboration and cooperation amongst organizations and countries.

The **Innovative Achievement Award** was presented this year to **Mr. Chris Hatton**, Director of Repository Design and Development at the Nuclear Waste Management Organization, for his achievements in the design of engineered barriers for the long-term containment of used nuclear fuel. His novel proposal of a canister design and accompanying buffer material for use in Canada's Deep Geologic Repository places Canada at the forefront of engineered barrier design for used fuel repositories. Mr. Hatton's innovative achievement has potential value to Canadians through cost savings, world-leading R&D opportunities, and an engaged domestic supply chain.

Dr. Greg Rzentkowski, currently the Director of the Division of Nuclear Installation Safety at the IAEA and previously the Director General of the Directorate of Power Reactor Regulation at the CNSC, was presented the **George C. Laurence Award for Nuclear Safety**, for his outstanding contributions in promoting a high level of safety in the nuclear industry in Canada and internationally. Under Dr. Rzentkowski's leadership and vision, Canada was amongst the first nuclear regulatory regimes to bring industry together to identify vulnerabilities and to propose and implement effective actions to avoid or mitigate the outcomes of a severe accident involving a Nuclear Power Plant in the Canadian fleet, post Fukushima. Furthermore, he made a significant contribution to pragmatically improve and maintain the Canadian nuclear industry level of safety profile at home and abroad.

The **Education and Communication Award** was presented this year to **Dr. Anthony Waker**, Professor at University of Ontario Institute of Technology, for commitment to training highly-qualified personnel, and for public outreach concerning the science underlying radiation-protection philosophies. Throughout his career, Dr. Waker has passionately transferred his unique expertise in Radiation Physics, Medical Physics and Health Physics to his students, who benefited from his strong support and mentoring. Through his public outreach, Tony frequently discusses radiation dosimetry and radiation protection philosophies with non-technical audiences.

The **John S. Hewitt Team Achievement Award** was presented this year to a team of dedicated **New Brunswick Power and Atlantic Nuclear Inc. staff**, for innovation and strong teamwork in the delivery of the first CANDU 6 Fuel Handling Full-Scope Training Simulator. The benefits of this product have been recognized by new operator trainees who are able to train and qualify themselves for production work, in a low risk and learner-fertile environment. The simulator has also been used to verify operational and emergency procedures, and to develop operations documentation.

NB Power, Atlantic Nuclear, JS Hewitt Team Achievement Award.

CNS Fellow Frank Doyle.

CNS Fellow Ron Thomas.

CNS Fellow Syed Zaidi.

Mr. Frank W. Doyle, **Mr. Ronald A. Thomas and Mr. Syed M. H. Zaidi** were presented as **Fellows of the Canadian Nuclear Society** for their extensive contributions in the service of the Canadian Nuclear Society and the nuclear industry. **Mr. Frank Doyle**, Senior Advisor at CANDU Owners Group, has been a long-standing member of the Canadian Nuclear Society, and has served on and chaired many committees. During his CNS Presidency in 2011-2012, the Society delivered six major conferences and two courses, published the inaugural edition of the CNS Nuclear Canada Yearbook and released a commemorative documentary on Lord Rutherford. Frank was also instrumental in bringing the Pacific Basin Nuclear Conference (PBNC) to Vancouver in 2014, and ensuring its enormous success through his leadership as International Chair. **Mr. Ron Thomas** began his career at the Atomic Energy Control Board (now the CNSC) and was involved in the development of Canadian and International standards in nuclear power plant quality assurance and nuclear pressure-retaining components. He has made extensive contributions to the Society as an active member of the CNS Ottawa Branch for over 10 years, where he was instrumental in the development of various Branch Outreach and Educational Programs. **Mr. Syed Zaidi**, retired from Atomic Energy of Canada Limited, has been an active CNS member for more than ten years. He was elected on the CNS Council in 2006 and became the Chair of the CNS Branch Affairs Committee in 2007. Syed was instrumental in the creation of the Western Branch in 2013, in guiding new Branch Chairs, and in helping branches succeed and thrive in organizing technical and non-technical events and participating in various outreach activities.

The final presentation was for the **R.E. Jervis Award**, which was awarded to **Mr. Eugene Saltanov**, a PhD candidate at University of Ontario Institute of Technology, in recognition of excellence in his research and in all his academic pursuits. Mr. Saltanov is the recipient of this award for his research work on Generation IV nuclear reactor concepts (the Super Critical Water-Cooled Reactor in particular). His current PhD research is titled "Specifics of forced convective heat transfer to supercritical carbon dioxide flowing upwards in vertical bare tubes". Eugene is not only accomplished academically - 41 publications, including conference papers, technical reports and manuscripts for publication, bearing his name - but he also participates and volunteers in the Canadian Nuclear Society and other organizations, tutors, plays the flute and alto saxophone, futsal (five-a-side soccer) and does video-shooting and editing.

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 2016 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!

Top row (left to right): Jacques Plourde (CNS President 2014-2015), Stephen Somerville, Murat Usalp (ANI, now WorleyParsons), Jeff McInerney (NB Power), Elif Can Usalp (ANI, now WorleyParsons), Eugene Saltanov (UOIT), John Barrett (CNA President), George Bereznai (UOIT, accepting award on behalf of Anthony Waker).

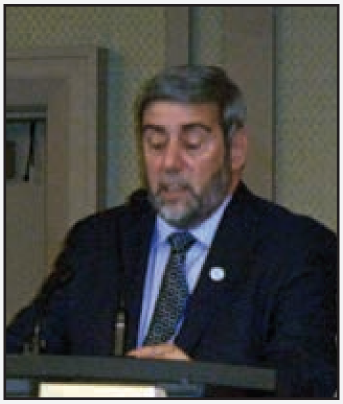
Bottom row (left to right): Chris Hatton (NWMO), Frank Doyle (COG), Laurence Leung (CNL), Robert Walker (CNL), Jin Jiang (Western University), Syed Zaidi (retired AECL).

1st FSEP Draws Strong Domestic, International Participation

by COLIN HUNT

The 1st International Technical Meeting on Fire Safety and Emergency Preparedness for the Nuclear Industry (FSEP) drew a strong domestic and international attendance to its inaugural meeting on Wednesday, June 17, 2015. The conference was held at the Hilton Meadowvale in Mississauga, Ontario.

More than 120 attended this first conference of its kind to be held by the Canadian Nuclear Society (CNS). It included a large attendance from Canadian utilities, Canadian and international regulatory authorities and suppliers. The program included two full days of plenary and parallel technical sessions, the opening reception on Wednesday, and a dinner for all conference attendees on Thursday evening.



Honorary Conference Chair Jacques Plourde.

Conference Chair Tracy Lapping.

The conference was opened at the Wednesday reception by Acting Honorary Chair Jacques Plourde, Past President of the CNS. He welcomed everyone on behalf of the Society to this first conference of its kind offered by the CNS. He was joined in his remarks by Conference Chair Tracy Lapping. He noted that Ms. Lapping was the principal creator of the conference. Ms. Lapping was also the CNS Council's Program Committee Chair, and this conference was an initiative undertaken by her during her first year on CNS Council.

Mr. Plourde noted that the issue of fire safety and emergency preparedness had assumed considerably greater importance for the nuclear industry, both in Canada and around the world, since the accident at Fukushima Daiichi in Japan in 2011. As a consequence, he stated that this conference was of interest and applicable to all nuclear utilities, not just those in Canada.

Don Trylinski welcomes delegates to 1st International FSEP.

Dave Nodwell, Office of the Fire Marshal.

Jim Coles, Ontario Power Generation.

In her remarks, Ms. Lapping thanked the strong support of her sponsors: Bruce Power, PLC Fire Safety Solutions, Ontario Power Generation (OPG), and Victaulic. She also thanked her organizing committee: Don Trylinski, Grant Cherkas, Cheryl McCulloch, Ivan Bollinger, Jacques Plourde, Jeremy Whitlock, Shahina Kurien, Dan McArthur, Doug Tennant, Robert Elliott, Scott Robertson and Ben Rouben.

Ms. Lapping noted that Greg Rzentkowski of the Canadian Nuclear Safety Commission (CNSC) was the original Honorary Chair, but was compelled to withdraw very shortly before the conference because of his appointment to an overseas post. Ms. Lapping also thanked her technical program chairs Rudy Cronk and Garry Fowles for their work in assembling the technical program.

The full program of the conference began with the opening plenary session on Thursday morning. Following opening remarks by Mr. Plourde and Ms. Lapping, Dave Nodwell, Office of the Ontario Fire Marshal and Emergency Management, gave an initial presentation on unified response to large scale disasters. His pre-

John Osborne, CNL.

Dan McArthur, Bruce Power.

Luke Morrison, PLC Fire Safety Solutions.

Scott Robertson, NB Power.

sentation featured a large, full scale test of the emergency response system in Ontario performed at the Darlington nuclear power station earlier in the year.

He was followed by Jim Coles, Director of Emergency Management and Fire Protection, OPG, and John Collin, Chief of Emergency and Protective Service, Bruce Power. Mr. Coles and Mr. Collin outlined steps that Ontario's nuclear operators had taken in the wake of the events at Fukushima. The general thrust of their presentations was that it was no longer sufficient for nuclear operators to restrict their safety analysis to design basis events but was essential to consider beyond design basis events.

The opening plenary session was followed by seven parallel technical sessions, four on Thursday afternoon and three on Friday afternoon. The technical sessions covered a variety of topics including: codes and standards, regulatory affairs, strategic considerations, existing and emerging technology, risk management, operating experience, fire prevention, safety analysis and many more.

The Friday morning plenary session included John Osborne of Canadian Nuclear Laboratories (CNL), Dan McArthur, Bruce Power, Luke Morrison, President PLC Fire Safety Solutions, and Scott Robertson, New Brunswick Power. Mr. McArthur noted the evolution of emergency response at Bruce Power following the events at Fukushima, while Mr. Robertson provided an interesting view of the unique challenges confronting small nuclear utilities to provide a strong response to the needs emerging from the Fukushima events.

The conference also presented international experience. Mr. Vasilica Simionescu of the Cernavoda NPP in Romania gave a presentation on his station's response to Fukushima events as well as the need to meet European Union stress test requirements. The Romanian regulatory authority was also in attendance at the conference.

The conference was supported by a broad range of exhibitors including Bruce Power, Darch Fire Inc., EPM Inc., Fauske & Associates LLP, KLD Engineering PC, Firefighting in Canada, Troy Life, Fire & Safely Ltd., Nuvia Canada Inc., PLC Fire Safety Solutions, RTI International and Victaulic.

The opening Plenary session.

Thursday night banquet.

Friday's Plenary session.

Sustainable Uranium Energy – an Optional Future

by DAN MENELEY[1]

[Ed. Note: The following paper was originally presented at the closing plenary session of the Fourth EIC Climate Change Technology conference, Montreal, PQ, May 27, 2015. Submitted by the Author.]

Introduction

After 50 plus years of working on uranium fission principles and application, it is a bit hard for me to talk about anything else – but I'll give it a try. To start, I solemnly promise not to recommend to you any new reactor design – be it small, medium, modular, or large. The Uranium-fuelled power plant will be discussed ONLY as a finished product. Note that this sketch is an optional future. Ontario will, of course, take it or leave it, in whole or in part.

This paper concentrates on future potential achievements of the CANDU nuclear energy systems. In the past, this venture has produced several modular systems, ranging from small (NPD and CANDU 3), medium (CANDU 6 and 6E) and large (Bruce, Darlington, and CANDU 9). All of these projects are more or less finished products, and yet the CANDU concept still has broad scope for refinement and upgrading. This paper is, however, not about nuclear technology *per se*, but rather it is about what nuclear energy can do, both now and in the future.

What does Ontario need to do next, in the line of technology applications that can help deal with the negative aspects of human-induced climate change? What energy systems can be installed to sustain the wealth and prosperity that Ontario's citizens now enjoy? What are the opportunities and the engineering challenges ahead of us? I do wish to apologize in advance for errors and omissions, and can only hope that missed details do not detract nor completely destroy an optimistic vision.

Energy engineering is my game. Economics is not my specialty though it is an integral part of every engineering project. It is likely that the topic of economics will dominate the future choice of world energy supply, whatever that choice may be.

Some people claim that the decisive factor dominating decisions with respect to uranium energy will be fear. In fact many opponents of the associated technology aim to induce fear as their main guiding theme. On the contrary, it is more reasonable to expect the rest of the world to follow Russia, India and China plus a few other countries that already recognize other, larger, risks following from energy shortages. Eventually, we too in Canada will recognize these larger risks that are foreseeable even today. Survival fear will overcome lesser fears.

Figure 1: Ontario Electrical Supply by Source (2014).

Energy Resources in Ontario and the World

First comes uranium – the proverbial and unmentionable elephant in the room. It was adopted in Ontario just in time and now provides sixty percent of the province's electricity. Waterpower contributes about twenty-five percent and natural gas adds about nine percent. Wind comes next at five percent (not to mention its intermittence) and finally biofuel at one percent. Solar power also is planned, as yet another minor contributor.

Ontario already utilizes the largest part of its available waterpower resources. Until about 40 years ago, expansion of hydraulic supply offered a sound answer to our steadily growing needs. Around that time the province fell back on coal (Ontario Hydro's original energy source) as well as on oil and gas – all imported. Coal and oil suffer disadvantages due to relatively their low energy density, which makes fuel transportation expensive. Electricity is the most important energy currency now available for bulk interprovincial transfer. Hydrogen is the second ideal currency identified by David Scott [1]; in the short term, liquid hydocarbons are likely to be preferred because of relative stability and ease of transportation. Seasonal variations in output caused by water's generating capacity limits lead to the necessity for export of electricity from Ontario to Quebec at some times during some years.

1 UOIT

Figure 2: Bruce Nuclear Power Development site on Lake Huron, 2014.

Ontario has one substantial energy source. Fortunately, uranium exists in abundance in this province.

Much of the world outside Ontario is somewhat better off for oil and natural gas resources. Coal probably is the largest unused fossil resource – once again with some obvious limitations. Water resources are plentiful in some areas but suffer from their inability to choose either the generation location or output scale to suit local needs, plus being sensitive to drought. In many cases transmission and/or transportation distances limit their usefulness. Uranium is widely distributed around the world, and its high potential energy content eliminates international fuel transportation problems. Condenser cooling water supply can be a limiting factor.

When the need for large scale application of this technology is realized, one of the early requirements will be for location of a few large energy centres around the world, [2] coupled with a large number of smaller (single-unit?) stations – a hub-and-spoke system. Each large energy centre may include a number of generating units along with their support facilities such as training, maintenance, and security systems.

The Bruce site today, shown here, offers an example of how such a major facility might begin. Note that the Bruce Energy Centre is located adjacent to this site – it was a pioneering effort to broaden the usefulness of uranium energy beyond mere electricity production.

The Wind Option

But what about our much advertised wind resources? Reality is slowly seeping into this situation [3]. The new UK government plans to stop approval of new land-based wind generators on land because of their visual and physical effects on living space. Serious problems are already surfacing in Germany [4], showing that the total installed capacity of wind energy will soon reach its limit in that country.

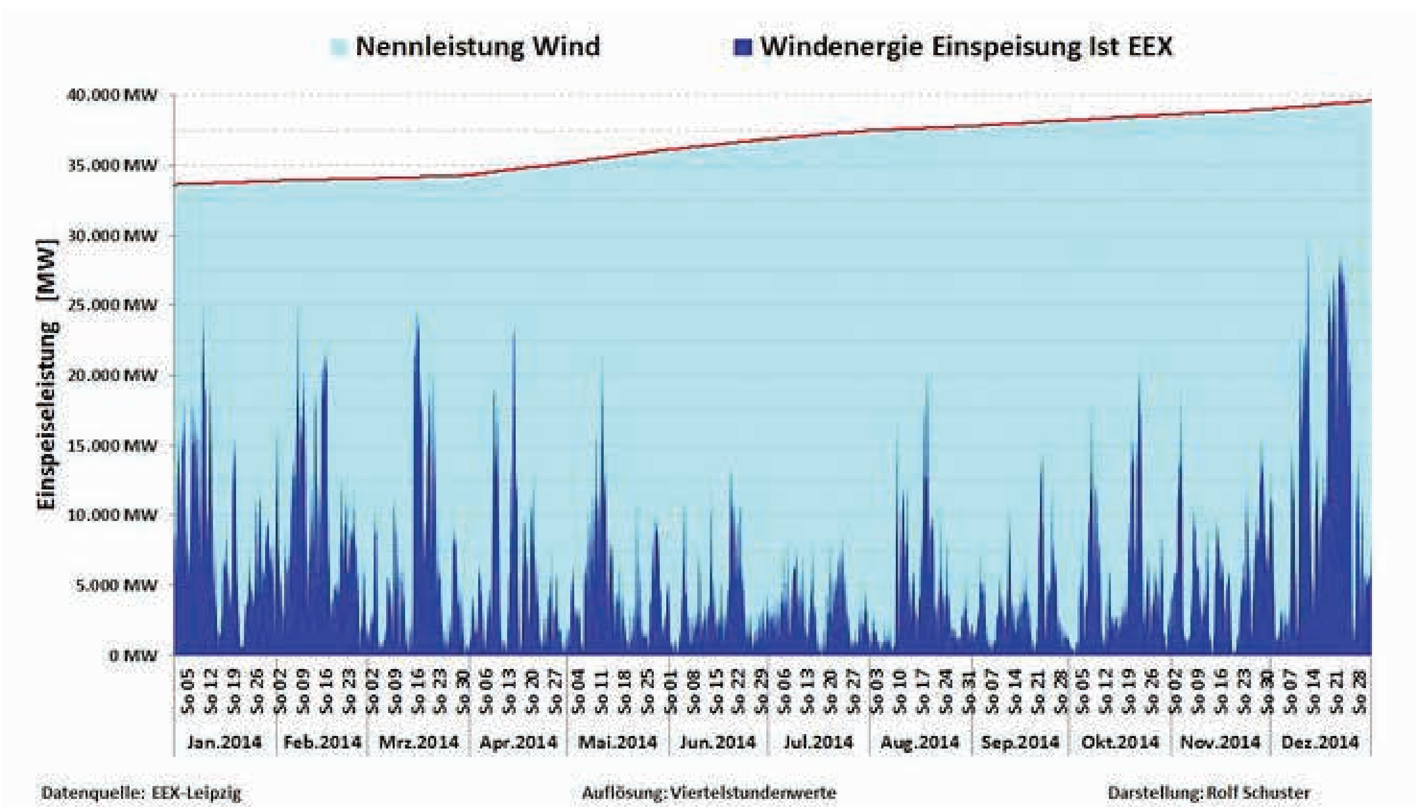


Figure 3: Germany's 2014 installed wind turbine rated capacity (shaded light blue), and the actual power fed in (dark blue). The average capacity factor over the year was 14.8 percent. (The compressed time scale of this graph hides the extreme variability of wind power production over times scales of seconds to minutes.)

Figure 4: Site & surroundings of the 3524 MWe Darlington station on Lake Ontario.

Daily, weekly, and seasonal energy storage is the obvious answer to the problem of wind generation, but as yet there exists no feasible method of large-scale electrical storage. Storage of hydrogen in natural gas pipelines in times of high winds (gas is needed to provide backup during intermittent calm periods) shows some promise but the safety of this practice is a major unknown [5].

This erratic pattern of energy production can be smoothed to some extent by installing a backup system such as natural gas turbines – but at a cost. In addition, emissions from leakage from natural gas systems can negate all the clean-air advantages of wind power [6]; leading to a wind/gas power system that emits more harmful GHGs than does a system powered by coal.

All of our natural gas is imported into Ontario. This import will likely continue in the future, as long as this fuel gas is available. Is there an alternative? (Once again I must mention the unmentionable.) Natural uranium is cheap, and so electricity produced in CANDU reactors includes only a small fuel cost. It follows that incremental capacity of uranium-fuelled generators is a candidate for water splitting to produce hydrogen. Carbon addition to the hydrogen stream results in a relatively stable product known as methane (a.k.a. natural gas). This product can be delivered directly into existing and future natural gas pipelines. Presto! We can now have backup energy to support wind generation plus an eternal supply of natural gas for use in its own right. Furthermore, methane can be liquefied to produce synthetic petroleum. Carbon can be recovered from the atmosphere so that this coupled energy system remains carbon-neutral [7].

When we talk about replacement of fossil fuels by manufactured fuel such as uranium, we must always remember the enormous amount of energy stored as a small amount of mass, revealed in the famous equation $E = mc^2$. We have become used to extracting energy from mass that was created long ago. For example, in the upper crust of the earth heat (released mostly in the process of radioactive decay) and pressure (maintained by the force of gravity) plus the heat released from distortion of the earth as it rotates around the sun, converted organic materials into oil and gas. With the addition of oxygen to refined oil we once again convert this mass to energy for our use. Splitting water reverses this process and gives us stored energy in the form of mass. All energy storage systems are identical in this respect, of course, and all of these processes operate at less than 100% efficiency. The relative cost of conversion from one form to the other depends on the fuel cost and process efficiency as well as on the cost of mechanisms required to do the job.

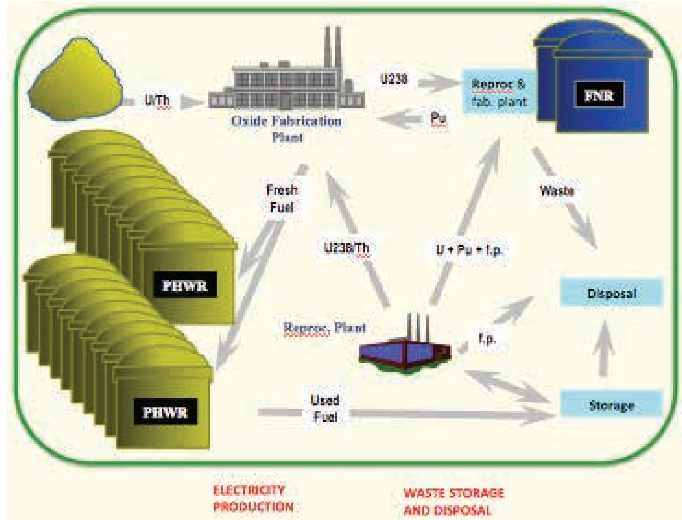


Figure 5: Conceptual diagram of a nuclear energy centre in the year 2100.

A second possible location for a large energy centre is the Darlington site on Lake Ontario, as shown in this satellite image.

To give an idea of the scale of electrical systems required, the direct energy equivalent of 16 billion liters of gasoline, the amount consumed in Ontario in 2013, [8] is equal to the electrical energy output of about 28 large (1.0 GWe) uranium-fuelled units operating at full power. In other words, Ontario's annual gasoline demand corresponds roughly to the net electrical output of eight Darlington stations, each powered by four CANDU units producing 881 MWe(net), assuming 90% capacity factor and 80% conversion efficiency from water to gasoline. Diesel fuel consumption would demand four additional Darlington stations.

It is quite obvious that total replacement of oil consumption will be a large task, probably requiring the application of every available energy source. Creation of a fossil-fuel-free energy system will be a gradual process, even though it is inevitable in the long run. Both fossil fuel resources and GHG limits will slowly decrease as time goes on. Fortunately, our uranium resources are more than adequate to meet a large portion of this challenge. Uranium, and of course Thorium, are the only inexhaustible energy resources [9] large enough to replace fossil fuels.

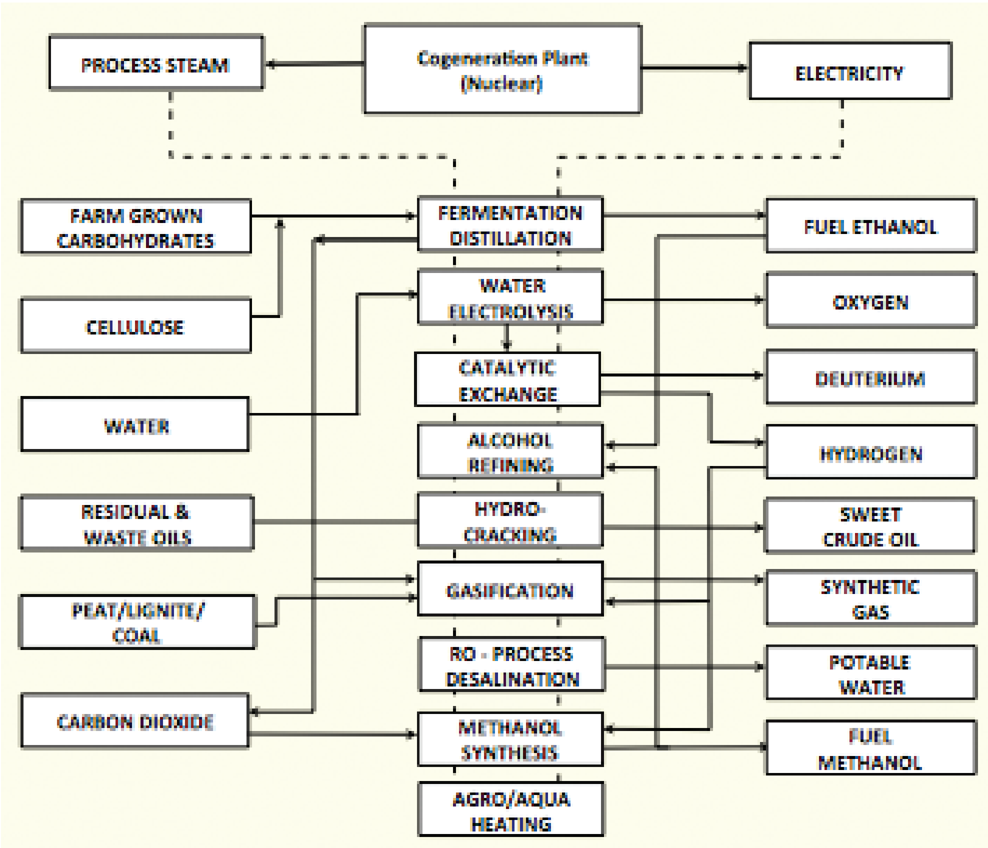


Figure 6: Original Bruce Energy Centre cascade, showing raw materials & products.

Shown here is a possible extension of the Bruce site, seen around the year 2100. Many more reactors and other facilities are included on or around the present-day site. The majority of fission reactors present on this site will be of CANDU design or slightly evolved versions of the units in service today. Canada cannot embark on development of a brand new design concept. We have much important work to do in growing our total uranium energy generating capacity.

By 2100 or thereabouts, it will be possible to include fuel fabrication, reprocessing, and waste disposal on or around the site utilizing borehole disposal of "true" waste products [10].

All of the facilities pictured here are directly associated with the production of electricity and process heat. The units colored in blue use fast neutron reactors [11], introduced to extend the uranium/thorium energy supply into the indefinite future and to properly manage used uranium fuel from CANDU reactors.

Gary Gurbin and Ken Talbot published the original paper [12] from which Figure 6 is copied. The "energy cascade" shows some expansion options made possible by the virtually limitless source of uranium energy. Aside from the obvious electrical link, the Bruce Energy Centre originators foresaw excess thermal energy being drawn from the then-existing Bruce A units. A large diameter pipeline was constructed to supply steam to the Energy Centre. This dream never came to full reality, apparently because British Energy rejected the idea of delivering steam to the BEC from the Bruce A station when they leased the Bruce site from Ontario Power Generation.

The site configuration shown in Figure 5 can be seen as a sustainable entity [13] with input of natural fuels and output of electricity and synthetic petroleum, as the market requires. Small amounts of uranium and/or thorium must be shipped to the site to compensate for atoms actually undergoing fission – less than 1/100 as much tonnage as today's CANDU units require per unit of energy output.

Further extension of the site is possible using today's technology, to include manufacture of synthetic oil and gas [14] industrial and agricultural chemicals, and even fish farming at the low-temperature end of the cascade.

Objective

Industrial re-development for Ontario, sustainable in the long term. This is our goal. Many other pathways could be chosen, but the common requirements of any choice will be abundant, reliable, economical electricity and transportation fuel. Uranium can do this. Stick with CANDU. It's a winner, and it's ours.

This recommendation is not to disparage developers of new reactor types -- it is just that Canada now has neither the need, the time, nor the money for a new nuclear energy concept. CANDU is "good enough for now". We need to improve its load cycling capability, both short term and seasonal. This can be done. We need to defend our record on proliferation – it is a good one.

Manufacturing synthetic petroleum is an energy-intensive industry due to the process of converting energy to mass, according to Einstein's famous equation ($E=mc^2$). Aside from inevitable efficiency losses inherent in this conversion process, the stored energy - after being converted to mass - remains in the gasoline or diesel product, to be released later on as needed. It is stored in a form the same as nature has stored it for millions of years. It works.

Water splitting and synthesis can be utilized both for load peaking and for transportation fuels. Cost? This is the final question. The answer is in our hands.

A combined CANDU and FNR fuel cycle requires only 1 percent as much mined uranium as today's once-through CANDU fuel cycle. If Step 4 is achieved and a sustainable combined cycle is established, all uranium (depleted or not) now on the surface can EVENTUALLY be used up – it will take a long time, given any projected total capacity, because of the huge energy yield per ton of uranium within the FNR fuel cycle.

Herein is a major development program that may well take 40 years to implement. Avoid diluting our limited resources by engaging in more design concepts. Our descendants probably will think up new and more effective ways to produce the energy they need, BUT — Just in case they do not, uranium fission systems can deliver energy to the world, at essentially any production level, forever.

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The Design, Construction, and Commissioning of a Multi-Use Cyclotron Facility

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Abstract

The Sylvia Fedoruk Canadian Centre for Nuclear Innovation in Saskatchewan is in the process of commissioning the Saskatchewan Centre for Cyclotron Sciences that is to be used for both academic research and commercial radiopharmaceutical production. The hybrid nature of this facility comes with unique challenges in satisfying both the rigid demands of pharmaceutical production while providing the necessary flexibility for academic research. In order to meet these competing demands, the Fedoruk Centre has assembled a distinct combination of skill sets and areas of expertise to operate a facility with an interdisciplinary focus.

1. Introduction

The Sylvia Fedoruk Canadian Centre for Nuclear Innovation, established in 2011, is based at the University of Saskatchewan in Saskatoon. The Fedoruk Centre has a mandate to place Canada and Saskatchewan among global leaders in nuclear research, development and training [1]. This is to be accomplished through a combination of partnerships with both academia and industry, with an emphasis on social and economic benefit, expressed in the following goals: "(1)building nuclear expertise and capacity through the support to academic programs and research projects in partnership with industry, academic institutions and research organizations in nuclear medicine, materials research, energy and the environment; (2) enhancing innovation in partnership with the research community and industry; (3) engaging communities and increasing understandings of risks, benefits, and potential impacts of nuclear technologies." [1]. The Fedoruk Centre is named after Saskatchewan researcher Sylvia Fedoruk, who was involved in development of cobalt-60 radiation therapy devices at the University in the early 1950's [1].

A major step in achieving these goals is in the bringing online of a 24 MeV cyclotron facility that is slated for Good Manufacturing Practices (GMP) production of commercially available radiopharmaceuticals such as the PET (Positron Emission Tomography) imaging agent ^{18}F-fluorodeoxyglucose (^{18}F-FDG) for Saskatchewan hospitals, as well as the ability to be heavily used by the surrounding research community.

2. Vision for the Facility

In March of 2011, funding from the federal and provincial governments was announced for a PET-CT (Positron Emission Tomography-Computed Tomography) scanner at Royal University Hospital in Saskatoon and the construction of a cyclotron on the University of Saskatchewan campus [1]. The physical proximity of these two sites allows for efficient use of cyclotron-produced radiopharmaceuticals. However, the vision for the cyclotron facility is much broader than providing ^{18}F radiopharmaceuticals to a local hospital, as this could have been achieved with a much smaller facility and a much less powerful cyclotron [1]. A 24 MeV cyclotron not only gives the capability to produce PET and SPECT (Single-Photon Emission Computed Tomography) tracers currently in clinical use, but is also able to produce more novel isotopes for research applications.

One of the first projects undertaken by the cyclotron team is to produce GMP grade ^{18}F-FDG for clinical use. ^{18}F-FDG is currently being used by the Medical Imaging Department at Royal University Hospital, but they are limited in their supply due to the need to ship the radiopharmaceutical over 2700 km. Once the facility is online and is able to produce ^{18}F-FDG under Health Canada's stringent GMP requirements, Royal University Hospital will have the flexibility of local ^{18}F-FDG and will not be limited by transportation hurdles.

The Advanced Cyclotron Systems Inc. (ACSI) TR-24 cyclotron is capable of utilizing solid, liquid, and gas targets, and therefore is capable of synthesizing a variety of radioisotopes including ^{18}F, ^{11}C, ^{13}N, SPECT and other exotic isotopes [1]. With many research groups already present at the University of Saskatchewan, the cyclotron has the potential to produce agents that are

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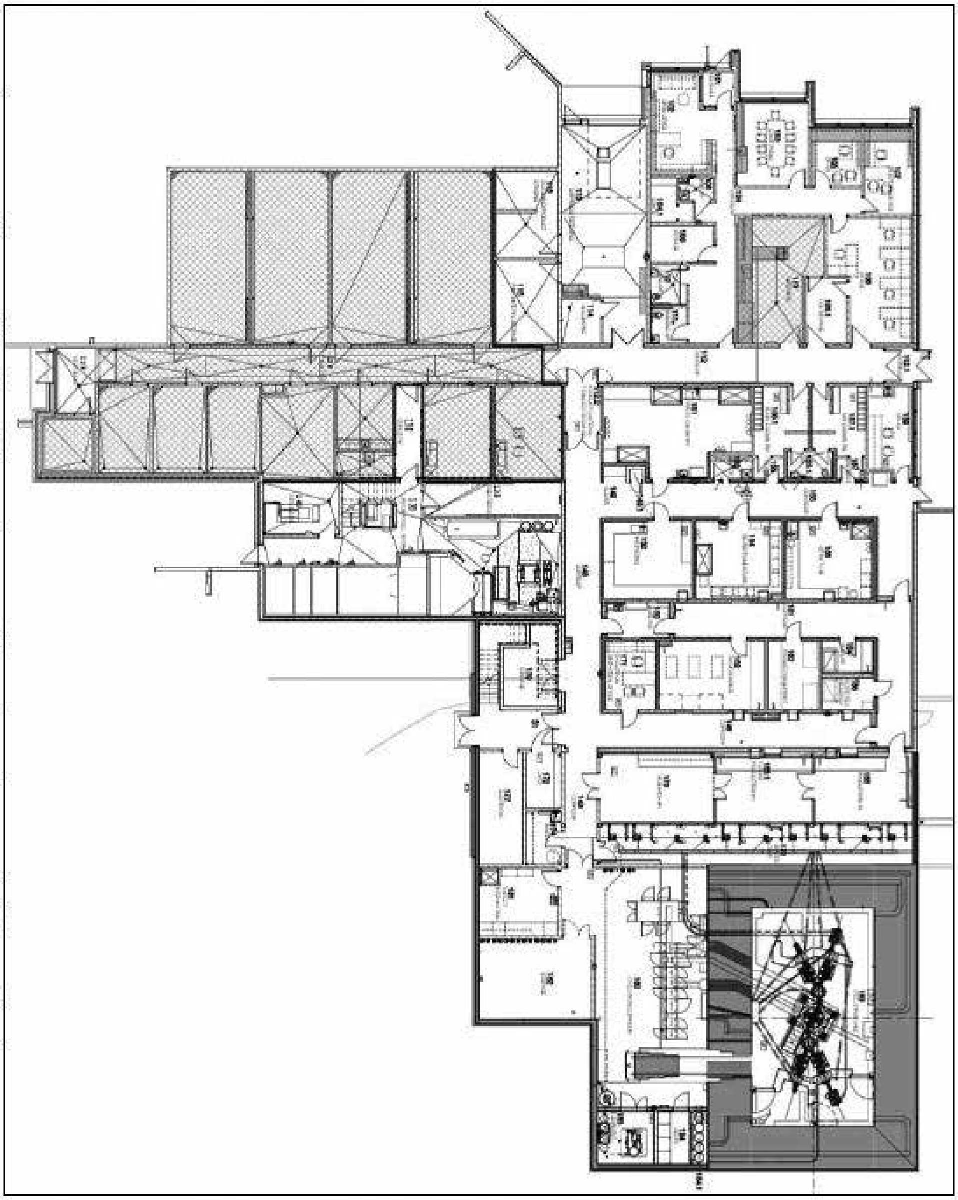

Figure 1: Floorplan of Saskatchewan Centre for Cyclotron Sciences.

useful for research in medicine, pharmacy, veterinary medicine, agriculture, and other life sciences [1].

The Saskatchewan Centre for Cyclotron Sciences is intended to accommodate many different research laboratories and projects, as well as room for future expansion. In addition to the lab space set aside for the GMP testing of ^{18}F-FDG, there is space in the clean zone of the facility allocated for blood cell or human tissue labelling, and for compounding of other radiopharmaceuticals. There is also space within the facility for a radiopharmacy and for future expansion and development of laboratories, including a micro PET-CT scanner and facilities for plant or small animal scanning. The segregation of the facility into a clean zone and regulated laboratories allows for the preparation of radioisotopes in sterile conditions, making them suitable for clinical use.

The Centre is designed to be supported in its research activities and endeavours by investments by the Fedoruk Centre for research positions at Saskatchewan universities [3]. There are plans and searches currently underway for faculty positions and research chairs at both the University of Saskatchewan in the fields of nuclear imaging and nuclear chemistry/radiopharmacy, and at the University of Regina in nuclear physics focused on detector development [3]. These positions will help provide guidance and direction to research endeavours undertaken at the Centre, as well as contribute to core cadre of researchers who will use the facility.

2.1 The ACSI TR-24 Cyclotron

The cyclotron at the heart of the facility is a 24 MeV TR-24 cyclotron produced by Advanced Cyclotron Systems, Inc., of Richmond, British Columbia. The acquisition of the cyclotron itself was a very large step for the University and for nuclear research in the province; Saskatchewan is among one of the final provinces to possess a cyclotron [4]. In a news article published in November of 2014, the radiopharmacist with the Saskatoon Health Region, Humphrey Fonge, is quoted as saying:

"This is going to blow out the amount of research opportunities the province is going to be having, the university is going to be having. We are actually one of the last provinces to get a cyclotron. But the nice thing is, we got the Ferrari. So we got one of the best cyclotrons at any academic institution. Depending on the amount of research done, it will rank us somewhere in the top 10 per cent of institutions that have similar facilities" [4].

The TR-24 cyclotron is equipped with a Y-shaped beamline ending in two end-stations; one with a solid target and the other equipped with a multiplex target selector. There is also a back-up set of targets that are available for PET products. There is room for expansion of the cyclotron and the addition of a second beamline and targets to further enhance production.

The ACSI TR-24 cyclotron is particularly suited to

Figure 2: View of the cyclotron and beamline from the vault entrance.

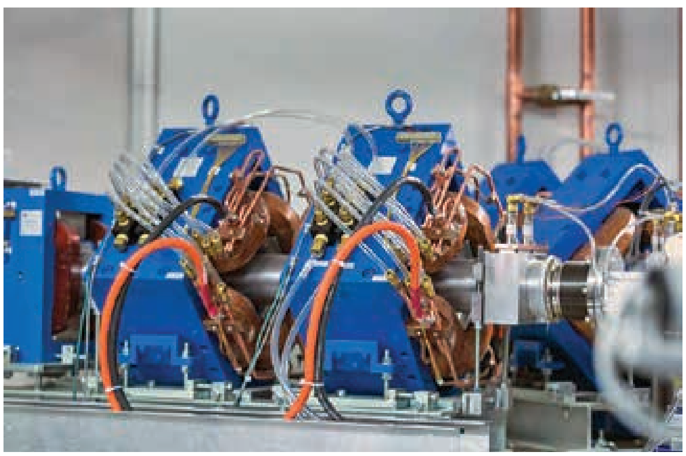

Figure 3: Quadrupole magnets on the cyclotron's beamline.

GMP production of ^{18}F due to particular characteristics of the water targets [5]. The Havar foils that are used in the liquid targets manufactured by ACSI for ^{18}O water bombardment are assembled with a thin layer of niobium that is thought to reduce the amount of water-based radicals produced during bombardment. This results in a purer product and actually optimizes the radiochemistry that is performed on the ^{18}F in the synthesis of the FDG [5]. This theorized capability of the TR-24 cyclotron is advantageous for GMP production, since it results in a product with fewer impurities and more consistent performance [5].

2.2 Challenges of a Multi-Use Facility

One significant challenge of having a multi-use facility is meeting the controlled standards that exist

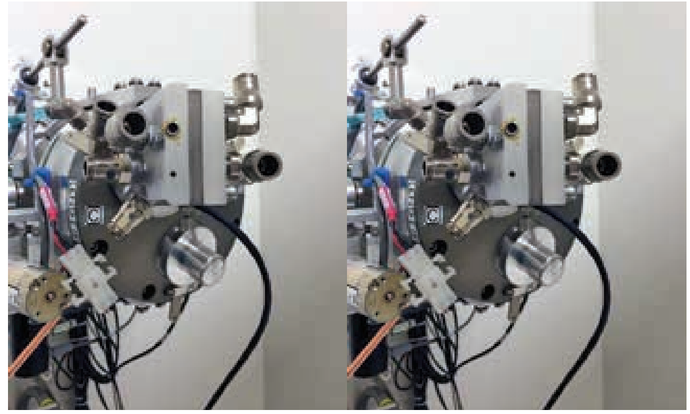

Figure 4: Target selector with mounted liquid target (not plumbed).

in the Health Canada GMP regulations that govern the premises, equipment, personnel, sanitation, raw materials testing, manufacturing control, quality control, packaged materials testing, finished product testing, records, samples, stability, and sterile product information for radiopharmaceuticals [6]. These rigorous standards have implications for the structural design of the building in everything from ventilation systems, types of paint and flooring, to the type of air filtration that is used, implications for how the facility is managed and controlled, and how tightly the use of equipment is managed [6]. The fact that the cyclotron facility will house several different laboratory spaces, can create a variety of radioisotopes, and will be utilised by different research groups creates a logistical challenge for keeping the GMP-critical areas controlled. The GMP-critical areas are required to undergo their own set of commissioning and validation, as well as the nuclear commissioning that is required of the entire site.

The complexity of GMP standards is something that is relatively new to cyclotron-based isotope production of Positron Emitting Radiopharmaceuticals (PER) [7]. ^{18}F-FDG is classified as a PER and is regulated by an Annex to the Good Manufacturing Practices [7,8]. PERs have additional complications due to their short half-lives and the hours-long lifespan of product, and therefore require different treatment as far as Quality Control testing and Final Product Release than typical GMP pharmaceuticals[8]. The speed of the decay and limited time of use allow for certain Quality Control tests to be completed in a retrospective manner.

We have found that the way to achieve a balance between GMP production and research flexibility is to bring together a unique interdisciplinary blend of talents to make the cyclotron facility as versatile as possible. The staff has a set of varied backgrounds including: cyclotron engineering, installation and repair; nuclear medicine and radiopharmaceutical production in a hospital setting; and GMP Quality Control and analytical chemistry of conventional pharmaceuticals. The partnership and collaboration that exists between the University of Saskatchewan, University of Regina and the Fedoruk Centre creates a powerful synergy--the universities can provide the expertise and the vision for research endeavours, and the Fedoruk Centre provides staff with the technical knowledge and skill to aid the researchers in producing and synthesizing isotopes or tracers that will aid them in their given fields of expertise. It is also envisioned that the facility will also be utilized by industry and researchers from outside of Saskatchewan, in partnership with the provincial user community. The Saskatchewan Centre for Cyclotron Sciences is intended to be a collaborative facility, where the Fedoruk Centre technical staff work alongside researchers to aid them in meeting their research goals. This goal will also be supplemented by the experience of the researchers working as part of the nuclear imaging programs being developed at the University of Saskatchewan and at the University of Regina [3].

In order to establish a cyclotron facility that is capable of meeting the requirements of GMP regulations for PERs and the differences in the production of radiopharmaceuticals with a short half-life compared to traditional pharmaceutical production, the Fedoruk Centre looked to find other Canadian expertise. The Fedoruk Centre has established a long-term partnership with the Centre for Probe Development and Commercialization (CPDC) at McMaster University in Hamilton, Ontario. The CPDC has a long-standing history of producing PET isotopes, and is assisting the Fedoruk Centre team with regulatory affairs, establishing an overall quality system, and overall production and testing of ^{18}F-FDG [1]. This relationship with an established PET isotope supplier with expertise in the nuances of clinical trials, automated production, and the engineering required to operate a cyclotron is allowing the Fedoruk Centre to adopt an already-proven system of production of ^{18}F-FDG, and provides a foundation for the potential GMP production of other tracers.

3. Conclusion

The Saskatchewan Centre for Cyclotron Sciences is the result of an interdisciplinary attempt and coming together of many different areas of expertise to achieve the goal of establishing a site in Saskatchewan that is sustainable and capable of meeting both research and commercial radiopharmaceutical production goals.

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Assessment of Disruptive Scenarios of a Canadian Used Fuel Repository in Crystalline Rock

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Abstract

The NWMO has recently extended its modelling capabilities by performing simulations for four disruptive scenarios that, to date, have not yet been examined in detail. These scenarios complement those considered in an existing postclosure safety assessment for a conceptual geological repository located in a hypothetical crystalline rock formation. The four new disruptive scenarios are: Shaft Seal Failure, Undetected Fault, Open or Poorly Sealed Borehole and Open Borehole Due to Inadvertent Human Intrusion. All simulations are based on the FRAC3DVS-OPG [1] Site-Scale Model [2]. The Site-Scale Model includes a simplified representation of the full repository and a portion of the surrounding sub-regional flow system. All transport simulations are performed with only the radionuclide I-129. Transport rates to the surface and a domestic water supply well are compared to the Reference Case results from an earlier case study documented in Reference [2].

1. Introduction

A postclosure safety assessment of a conceptual deep geological repository for used CANDU fuel at a hypothetical crystalline rock site in the Canadian Shield is documented in Reference [2]. It considers a repository at a depth of approximately 500m in a crystalline rock geosphere containing a network of fractures. The repository holds 4.6 million used fuel bundles in roughly 12,800 durable steel and copper IV-25 containers. The containers are placed in an in-floor configuration and all placement rooms, tunnels and shafts in the repository are backfilled with engineered sealing materials containing swelling montmorillonite rich clay called Bentonite. Figure 1 shows the conceptual repository design.

The purpose of a postclosure safety assessment is to determine the potential effects of the repository on the health and safety of persons and the environment. A one million year baseline is adopted as the timescale of interest based on the time needed for the used fuel radioactivity to decay to essentially the same level as that in an equivalent amount of natural uranium. However, postclosure safety assessment simulations

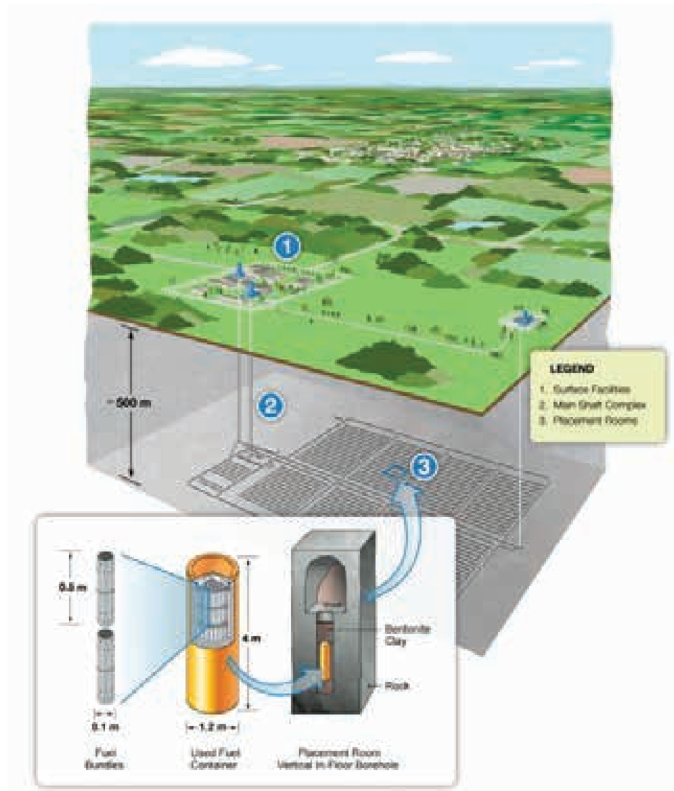

Figure 1: Conceptual Crystalline Rock Repository Design with IV-25 Containers.

are typically extended to 10 million years due to the low transport properties of the rock and to ensure peak doses are captured.

The postclosure safety assessment has been developed following regulatory guidance in CNSC G-320 [3] and is assessed through consideration of a set of potential future scenarios, where a scenario is a postulated or assumed set of conditions or events. In this way, a comprehensive range of possible future evolutions are examined against which the performance of the system can be assessed. Both Normal Evolution and Disruptive Event Scenarios are considered.

The Normal Evolution Scenario is based on a reasonable extrapolation of present day site features and receptor lifestyle, and represents the normal (or expected) evolution of the site and facility. Since gla-

1 Nuclear Waste Management Organization

ciation is expected to occur in the future, the Normal Evolution Scenario also includes a discussion of the effect of glaciation on calculated impacts [4]. The Reference Normal Evolution Scenario assumes the presence of a few containers with undetected manufacturing defects.

Disruptive Event Scenarios examine the effects of unlikely events that might lead to penetration of barriers, including the geosphere, and abnormal degradation and loss of containment. The disruptive scenarios of interest for the postclosure safety assessment in crystalline rock were identified following the procedure described in the next section.

2. Scenario Identification

The purpose of scenario identification is to develop a comprehensive range of possible future evolutions against which the performance of the system can be assessed.

Scenarios of interest are identified through consideration of the various factors that could affect the repository system and its evolution. These factors can be further categorized into Features, Events and Processes (FEPs) which are discussed in detail in [5]. FEPs can be characterized as either "external" or "internal", depending on whether they are outside or inside the spatial and temporal boundaries of the repository system domain, which here includes the repository, the geosphere and the affected biosphere. The "external" factors originate outside these boundaries; whereas those which originate inside these boundaries can be considered as "internal" factors.

The failure mechanism identified in the FEPs review [5] can be grouped into seven Disruptive Scenarios. Since the long-term safety of the repository is based on the strength of the geosphere and the engineered barriers (including the container and the shaft seals), the Disruptive Scenarios are typically based on circumstances in which these barriers might be significantly degraded or bypassed. The following Disruptive Event Scenarios have been identified as relevant to the hypothetical site and conceptual repository design:

1. Inadvertent Human Intrusion;
2. Open or Poorly Sealed Borehole;
3. Shaft Seal Failure;
4. Fracture Seal Failure;
5. Undetected Fracture or Fault;
6. Container Failure; and
7. All Containers Fail.

Disruptive Scenarios 1, 4, 6 and 7 were analyzed and documented in NWMO (2012). Scenario 3 was also analyzed in NWMO (2012) but in a simplistic manner and it has therefore been re-examined. The following Disruptive Scenarios are analyzed in this work:

1. Shaft Seal Failure;
2. Undetected Fault;
3. Open or Poorly Sealed Borehole; and
4. Open Borehole Due to Inadvertent Human Intrusion.

3. Reference Case Model Description

The Reference Case assumes three IV-25 containers are placed in the repository with small undetected manufacturing defects. Radionuclides are released from the defective containers once the repository has resaturated and the defective containers have filled with water (conservatively assumed to occur 100 years after closure). The defective containers are assumed to be placed in the location with the shortest transport time and the maximum radionuclide transport rate to a domestic water well. The water well is located in the position that maximizes uptake of the contaminant plume associated with the defective containers. The well pumps at a rate of 911 m^3/a, a rate sufficient to support the water demand of a self-sufficient farming family assumed to be living at the site. Doses to the self-sufficient farming family are dominated by I-129 and calculated using a variety of dose pathways. Reference [6] describes the Reference Case repository, geosphere material properties (e.g., porosity, permeability), radionuclide transport properties (e.g., sorption), and biosphere data. These same data are used in this assessment.

In this work, all Disruptive Scenario simulations were carried out using the finite-element, finite difference code FRAC3DVS-OPG [1] and are perturbations of the existing Reference Case Site-Scale Model documented in Reference [2]. The model domain contains a simplified representation of the full repository and a portion of the surrounding sub-regional flow system. Individual containers are not represented. The FRAC3DVS-OPG model domain consists of the repository footprint together with approximately 1500 m of surrounding geosphere that encompasses the repository influenced flow domain. Figure 2 shows the coordinate system and model boundaries. It also shows the projected particle tracks that illustrate the potential advective transport pathways for contaminants released from the repository. This information shows that the model domain includes all major discharge points. The primary discharges include the domestic water well, a river (shown below the repository in Figure 2), a lake (overlaying the bottom right corner of the repository in Figure 2) as well as wetlands near the repository location.

I-129 was the only radionuclide considered in the FRAC3DVS-OPG simulations as it was found to be the dominant dose contributor in all Normal Evolution and Disruptive Scenarios. This is because I-129 has a

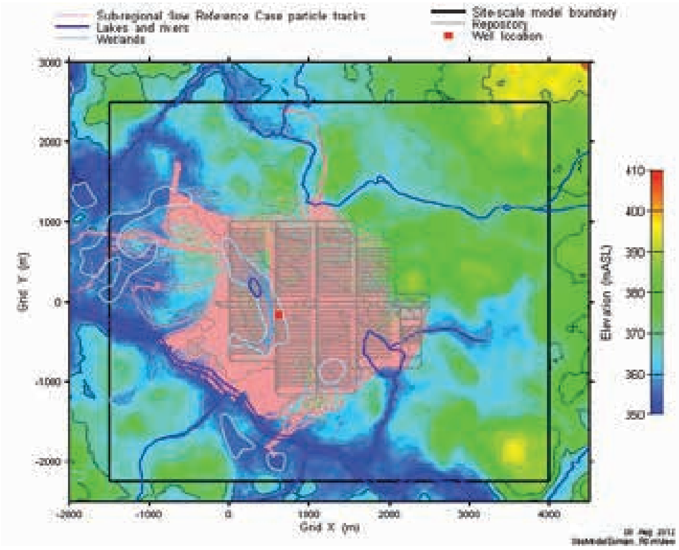

Figure 2: Site-Scale Model: Coordinate System and Domain Boundary.

sizeable initial inventory, a non-zero instant release fraction, a very long half-life, is non-sorbing in the buffer, backfill and geosphere and has a radiological impact on humans.

4. Shaft Seal Failure

The Shaft Seal Failure Disruptive Scenario simulations were run to determine the effects of degraded or failed shaft seals on the contaminant transport rates to the surface. In the conceptual repository, three shafts (main, service and ventilation) penetrate the geosphere. These shafts are placed away from the placement rooms and carefully sealed. The shaft seals consist of a low heat high performance concrete monolith at the base, a keyed in concrete bulkhead and a concrete capstone separated by layers of 70:30 bentonite clay:sand mix, and asphalt (Figure 3). The shafts are assumed to be surrounded by two regions of rock with increased transport properties that have been damaged by the shaft sinking process known as the inner and outer excavation damaged zone (EDZ).

The Shaft Seal Failure Scenario considers the possibility that the shaft seals are not fabricated or installed appropriately, or that the long-term performance of the shaft seals and shaft/repository Excavation Damage Zones (EDZ) is poor due to unexpected physical, chemical and/or biological processes. While either situation could result in an enhanced permeability pathway to the surface, both are very unlikely due to quality control measures that will be applied during shaft seal closure and due to the adoption of multiple durable material layers in the shaft.

4. Model Assumptions

The Shaft Seal Failure Disruptive Scenario focusses on

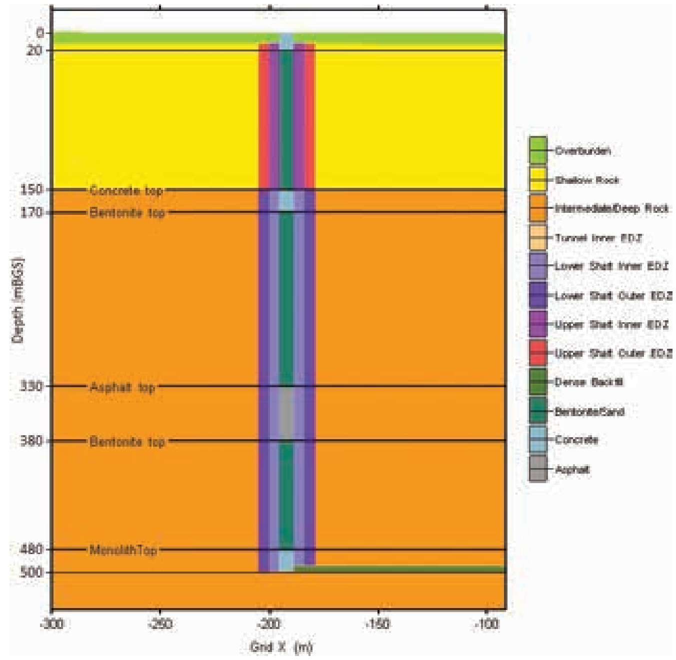

Figure 3: Ventilation Shaft Seal Design.

a ventilation shaft, the shaft closest to the failed containers. A variety of Shaft Seal Failure cases were analyzed. The first case examined was the Base Case, which is identical in all aspects to the Reference Case described in Section 2 except that the domestic water well was relocated to be entirely within the ventilation shaft.

The first set of cases examined the effect of degradation in the individual shaft sealing materials. The Asphalt Seal Failure Case looks at the effect of increasing the hydraulic conductivity of the asphalt seal from 10^{-12} m/s to 10^{-9} m/s (10^{-9} m/s is roughly equivalent to sandstone) and the Concrete/Bentonite Failure Case examines the effect of increasing the hydraulic conductivity of the concrete and bentonite- sand seals from 10^{-10} m/s and 4.8×10^{-13} m/s respectively to 10^{-9} m/s.

A second set of cases examined the effect of degradation in all the shaft seal materials. In the Damaged Seals Case all the materials in the shaft are assumed to be degraded and are modelled as a single material with a conductivity of 10^{-9} m/s and a porosity equivalent to the bentonite-sand seal (0.411). The Extremely Damaged Seals Case takes this one step further and increases the hydraulic conductivity of the seals by an additional factor of 100 over the Damaged Seals Case to 10^{-7} m/s (10^{-7} m/s is roughly equivalent to fine sand).

The third set of cases examined the influence of increasing the EDZ permeability in the repository and the shaft (EDZ Failure Case) and the combined effect of the increased EDZ conductivity and degraded shaft materials (EDZ/Shaft Failure Case). The EDZ Failure Case assumes the EDZ permeabilities are 100 times greater than in the Reference Case and the EDZ/Shaft Failure Case assumes the EDZ permeabilities are 100 times greater than in the Reference Case. The shaft

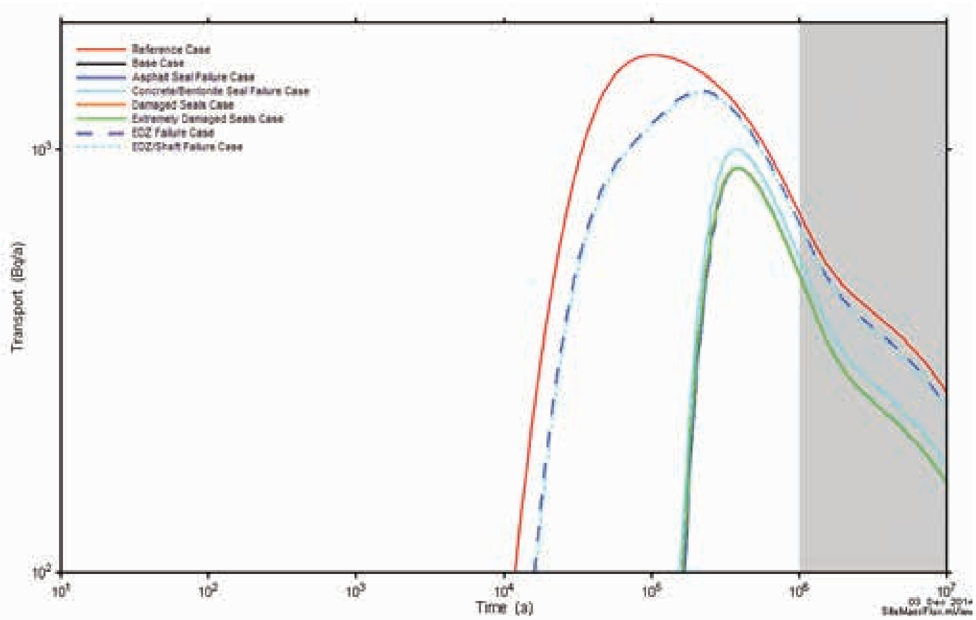

Figure 4: I-129 Well Transport Rate for All Shaft Seal Failure Sensitivity Cases.

seals are modelled as a single material with a hydraulic conductivity of 10^{-7} m/s and a porosity of 0.411.

4.2 Results

Figure 4 shows the transport rate to surface discharge zones for all cases described in Section 4.1 together with the Reference Case described in Section 2 for comparison. Relative to the Reference Case all of the shaft failure cases have lower peak I-129 transport rates to the surface. The reason for this is that the fracture that contains the well in the Reference Case is closer to the failed containers than the ventilation (closest) shaft. Like the Reference Case, the overwhelming majority of the transport to the surface for all the shaft failure cases occurs through the well with almost no discharge to the river or other surface discharge locations.

Figure 4 shows the peak transport rates to the surface for the Base Case, the Asphalt Seal Failure Case, the Concrete/Bentonite Seal Failure Case, and the Damaged Seals Case all produce very similar results. The Extremely Damaged Seals Case is similar but with a slightly higher peak transport rate than the previously mentioned cases. The EDZ Failure and the EDZ/Shaft Seal Failure Cases allow relatively fast transport through the repository excavation damage zones to the shaft and as a result produce the highest I-129 peak transport rates of all the Shaft Seal Failure Scenarios. However, these results are still less than those associated with the Reference Case due to the shorter overall transport path in the Reference Case.

5. Undetected Fault

The Undetected Fault Disruptive Scenario assumes a vertical fault is located adjacent and parallel to the placement room containing the defective containers. The undetected fault through the repository footprint (see Figure 5) effectively bypasses the geosphere barrier and allows transport of radionuclides to the surface via the fault.

5.1 Model Assumptions

The undetected fault is defined as a vertical fault adjacent and parallel to the placement room containing the defective containers. The fault is located 10m from the placement room wall, and is 100m long, beginning 10m from the cross-cut drift wall and extending past the defective containers. Vertically the fault extends from 100m below the repository to the surface, with an elliptical shape increasing with elevation as is characteristic for vertical faults. The fault intersects the fracture containing the Reference Case well. As the Reference Case well is almost directly above the room containing the defective container, the Reference Case well is 10 m from the undetected fault.

Several Undetected Fault cases were simulated to investigate the effect of an undetected fault with a variety of transport properties and well locations. The first case investigated was the Base Case in which all the model parameters are identical to the Reference Case values. The fault was assigned the same transport properties as the other fractures present in the geosphere (hydraulic conductivity of 10^{-6} m/s and a porosity of 0.1).

The two sensitivity cases examined the effect of fault hydraulic conductivity. In the Low Conductivity Case the fault conductivity was reduced by a factor of 10 to 10^{-7} m/s and in the High Conductivity Case the fault conductivity was increased to 10^{-5} m/s. All other model parameters remained at the Reference Case values. Another sensitivity case studied the influence of the well location on the transport rate to location to a location intersecting the Undetected Fault as close to the failed containers as possible. The final sensitivity case, the Well/High Conductivity Case, examined the combined influence of the modified well location from the Fault Well Case and the increased fault conductivity from the High Conductivity Case.

5.2 Results

The undetected fault provides a transport pathway to the surface similar to the nearby fracture in the Reference Case. However, since the undetected fault

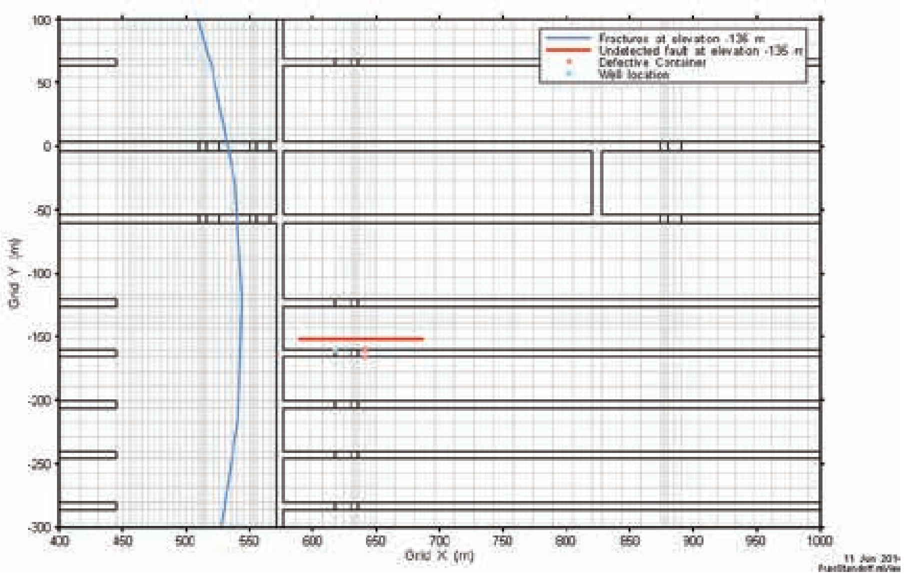

Figure 5: Undetected Fault Location.

is slightly closer to the failed containers than the Reference Case fracture, the peak transport rates for the undetected fault pathway occur roughly 30,000 years earlier. As in the Reference Case, the well is the primary discharge location, with very little mass reaching the other surface discharge locations in all variant cases except for those with increased hydraulic conductivity (i.e., High Conductivity and Well/High Conductivity Cases).

Figure 6 provides the total I-129 transport rate to the surface for the Undetected Fault Cases and the Reference Case described in Section 2. The peak I-129 transport rates are effectively the same between the Undetected Fault Cases and the Reference Case for most cases. Only the cases with increased hydraulic conductivity showed a slight increase in the peak transport rate to the surface. The cases with increased hydraulic conductivity are also unique in that a significant portion of the surface discharge is not captured by the well and is discharged into the river discharge. This is because the very high conductivity in the fault limits the influence of the well to the near-surface flow system and results in the well drawing in a significant quantity of fresh water.

Moving the well location to within the undetected fault has little effect on transport rates to the surface. This is not surprising given that the undetected fault intersects the same fracture where the well is located in the Reference Case. Lowering the conductivity in the undetected fault slowed the response to the well slightly and increased the transport time to the surface by roughly 7,500 years compared to the other Undetected Fault cases.

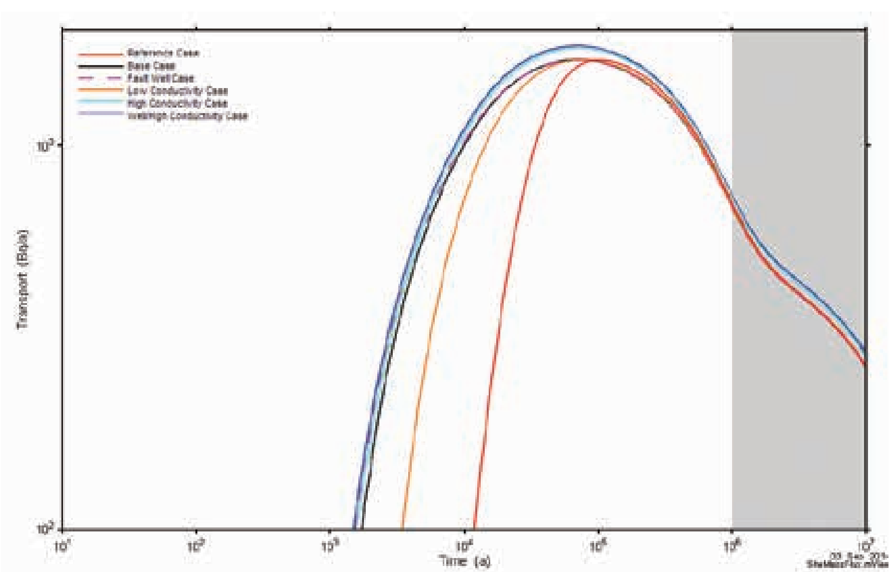

Figure 6: I-129 Total (Well and Surface Discharge) Transport Rate For all Undetected Fault Cases.

6 Open or Poorly Sealed Borehole

In the Open or Poorly Sealed Borehole scenario, the impact of an undetected, improperly sealed or abandoned exploration borehole, site exploration borehole or site monitoring borehole is assessed. These boreholes are located in the vicinity of the repository and may penetrate to below repository depth. These boreholes will be sealed on completion of site investigation or monitoring activities so they will not have any effect on repository performance. However, if a deep borehole were not properly sealed or if the seal was to extensively degrade, then it could provide a small but relatively permeable pathway for the migration of contaminants. Such a situation is very unlikely due to the adoption of good engineering practice and quality control.

6.1 Model Assumptions

This scenario explores the effects of incompletely sealed or unsealed boreholes. Three unique boreholes case are examined:

1. Exploration Borehole Case;
2. Site Characterization Borehole Case; and
3. Monitoring Borehole Case.

The Exploration Borehole Case assumes a vertical borehole with a hydraulic conductivity of 10^{-4} m/s and a porosity of 0.25 that has been drilled next to the defective container to a depth of 500m (i.e., the elevation of the repository floor). The borehole is arbitrarily offset 10m from the wall of the placement room, similar to the Undetected Fault

Case. The borehole intersects a fracture with connections to the Reference Case well. The water supply well is located at the Reference Case location.

The Site Characterization Borehole Case assumes a vertical borehole with a hydraulic conductivity of 10^{-4} m/s that is located within the repository footprint near the defective container and extends to repository depth. The borehole does not intersect a fracture and the discharge to the surface is assessed. The water supply well is located at the Reference Case location.

The Monitoring Borehole Case assumed an improperly sealed or abandoned site monitoring borehole with a hydraulic conductivity of 10^{-4} m/s located 50m outside the site footprint extending to repository depth. In this case the defective containers are conservatively relocated to the closest placement room location upgradient from the borehole. The water supply well is also conservatively relocated to intersect the same fracture as the monitoring borehole.

6.2 Results

Figure 7 provides the total transport rate to the surface for the various Open or Poorly Sealed Borehole cases. The only case with I-129 transport rates exceeding those of the Reference Case is the Exploration Borehole Case. This case resulted in earlier and slightly higher I-129 transport rates to the surface because the borehole was located closer to the failed containers than the fracture containing the well.

The Site Characterization Borehole Case had no influence on the transport rates and results were identical to the Reference Case. The monitoring borehole transport rates were significantly lower than the Reference Case primarily because of the increased distance between of the failed containers to the well relative to the Reference Case.

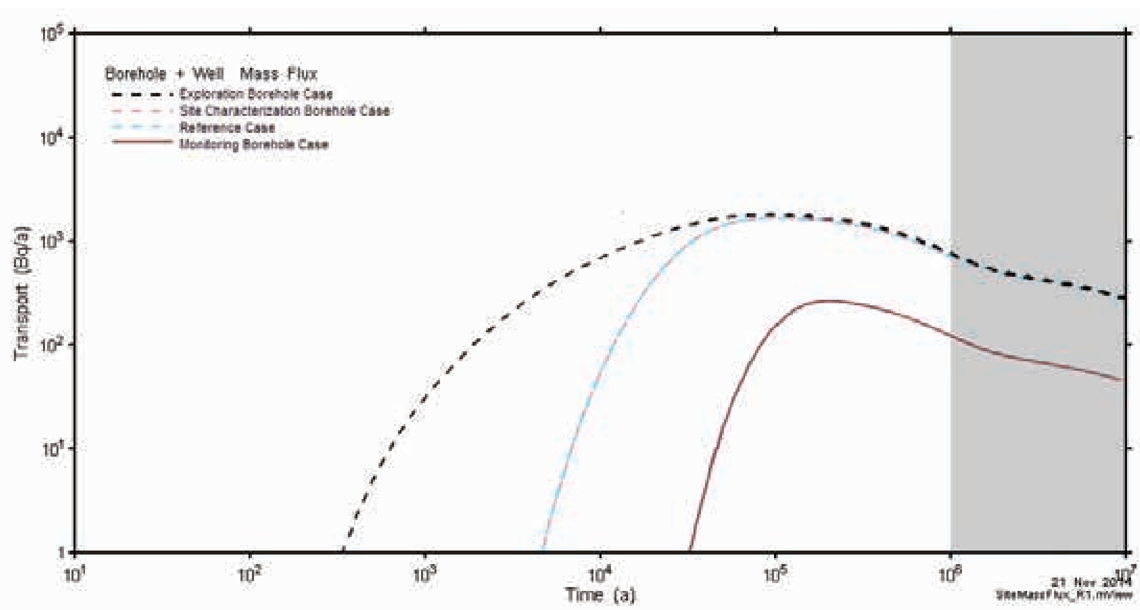

Figure 7: I-129 Total Transport Rate (Reference Case Well + Borehole) for Borehole Cases Compared with Reference Case Well.

7. Open Borehole Due to Inadvertent Human Intrusion

The Inadvertent Human Intrusion scenario considers an exploration borehole drilled into the repository, intersecting a used fuel container, and subsequently abandoned without any sealing or attempt at closure. Human intrusion results in the immediate release of contaminants from the damaged container; the scenarios presented here are intended to bound possible transport and dose consequences.

The effects of bringing fuel directly to the surface are separately assessed [2] and not discussed here. This work only examines the consequences assuming the borehole is not sealed.

7.1 Model Assumptions

The open Human Intrusion Borehole is assumed to intersect both the container in the location of one of the Reference Case defective containers and the fracture containing the water supply well. The borehole is simulated as a well line element with 10^{-4} m/s hydraulic conductivity and a porosity of 0.25.

In this case, the borehole bypasses all geological and engineered barriers and intersects the container. Doses resulting from this scenario may have significant contributions from species other than I-129. As a result, transport modelling was performed using a fixed unit concentration source at the defective container location to assess the contaminant uptake by the well over the entire simulation time. A fixed unit concentration source facilitates the dose calculation through scaling the results of the fixed unit source to other radionuclides.

Two cases were simulated to assess the effects. The Base Case used the Reference Case well location and the Variant Case used the borehole as the water supply well.

7.2 Results

Figure 8 shows the well transport rates for the Base Case and the Variant Case compared to the Reference Case (using a fixed unit concentration source). The contaminant input for each case varies depending on the ability of the flow field to reduce concentrations near the fixed- concentration source. In the Reference Case and the Base Case, the

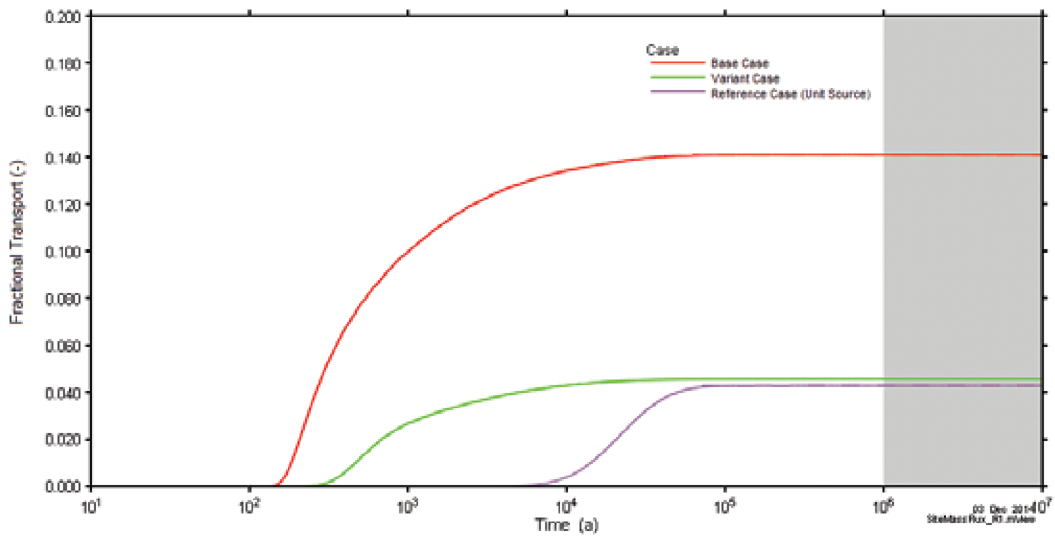

Figure 8: Open Human Intrusion Borehole Discharge Concentration.

well captures the vast majority of the source contaminant and there is essentially no transport to the other surface discharge locations. In the Variant Case, the well is also the dominant transport pathway to the surface; however, there is a non-negligible release to the other surface discharge locations.

In the Base Case, the open borehole provides a permeable pathway intersecting the fracture containing the well and greater transport occurs compared to the Variant Case. With the borehole acting as a well, the distribution of the well pumping rate along the whole length of the borehole and the lack of a well casing reduces the effect of the pumping on the flow field at depth. Consequently, some I-129 reaches other surface discharge locations. For the Variant Case, the transport rate to the well is almost the same as in the Reference Case and for the Base Case the transport rate to the well is approximately 3.5 times greater than for the Reference Case.

8. Conclusions

Four new Disruptive Scenarios in addition to those presented in [2] are assessed in this work:

1. Shaft Seal Failure;
2. Undetected Fault;
3. Open or Poorly Sealed Borehole; and
4. Open Borehole Due to Inadvertent Human Intrusion.

Many of the Disruptive Scenario cases emphasize the importance of a permeable feature near the location of the defective containers. In the Reference Case, this permeable feature is the vertical fracture containing the Reference Case well. If the disruptive scenario defined a permeable feature farther from the defective container than in the Reference Case fracture and well, such as in the Shaft Seal Failure Case, the resulting radionuclide transport rates would be lower than for the Reference Case. The Undetected Fault and Poorly or Open Borehole Cases (including Human Intrusion) added new permeable features closer to the defective containers than the Reference Case fracture and well which allowed for more rapid radionuclide transport to the surface discharge locations than in the Reference Case. The well was found to capture nearly all of the transport to the surface for most scenarios highlighting its importance. Only in cases where the permeable feature was assumed to have a high hydraulic conductivity were the other surface discharge zones found to have a significant contribution to the total transport to the surface.

In the future, the NWMO will continue to develop its scenario identification process as well as refine its models and approaches for the investigation of Disruptive Events as more site specific and repository design data becomes available.

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StarCore Nuclear Generation IV HTGR

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Abstract

StarCore Nuclear (StarCore) is developing a High Temperature Gas Cooled Reactor using TRISO fuel, prismatic graphite blocks and a helium primary loop. The design is currently evolving, with the intent of completing the conceptual design and submitting it to the Canadian Nuclear Safety Commission (CNSC) as part of a Vendor Design Review within one year. The paper will focus on the status and plans for the design of the reactor plant.

1. Introduction

The StarCore High Temperature Gas Cooled Reactor (HTGR) plant is based on the TRISO fuel originally developed in the United Kingdom, the United States and Germany in the 1960's, and then used in a wide variety of plants in many countries. These plants have been based on graphite-moderated fuel microsphere designs developed to meet various operational requirements. The TRISO fuel has received a lot of recent attention in the Next Generation Nuclear Plant (NGNP) program [1] [2], the HTGR plant initiative in South Africa [3]; the reactor program at Tsinghua University (INET) in China [4]; the reactor program at the Japan Atomic Energy Research Institute (JAERI) [5], the International Atomic Energy Authority (IAEA) [6], and others.

This recent activity has resulted in improved TRISO fuel specifications and performance, and it is now generally regarded that TRISO is a fuel suitable for an HTGR that will be deployed to remote sites. The design has a very steep negative temperature coefficient that causes an automatic reduction in reactivity as temperature increases, which drives the plant into a low power state if there is a loss of coolant flow. In this regard the IAEA has defined the HTGR as *"an inherently safe nuclear reactor concept with an easily understood safety basis that permits substantially reduced emergency planning requirements and improved siting flexibility compared to other nuclear technologies"* [6].

StarCore has been developing the reactor and plant systems over the last several years and has selected the TRISO fuel and a prismatic graphite reactor core design, rated at 35 MWth. The fuel, core design and other features use the same technology as developed in the NGNP program [1] [2], on which the US Department of Energy has spent more than $500 million.

This program continues as an R&D program at the Idaho National Laboratory (INL), who is currently completing qualification work on fuel, graphite and high temperature materials [2]. StarCore expects that the qualifications for its design will be proven for these three critical elements by the completion of that program. The operating reactors in Japan, HTTR [5], and China, HTR-10 [4], have many similarities with the StarCore design and have provided valuable insights into the design and operation of the plant.

AREVA is a major participant in the (NGNP) program [1], and the AREVA reactor was chosen by the NGNP Alliance over its rivals for further development [7]. The StarCore and AREVA designs have many similarities. Under contract with StarCore, AREVA will provide the reactor core, reactor vessel systems, and core components, along with reactor control systems and instrumentation for the StarCore reactor plants.

The StarCore reactor plant produces both electricity and thermal energy, and uses a three- stage energy transfer process (from helium to nitrogen and then from nitrogen to an air- breathing turbine) to generate electricity. The three-stage process is designed to prevent helium migration at the first stage heat exchanger by balancing pressure across this interface, to enable the use of a Brayton cycle and thus optimize thermal efficiency, and to allow the use of a readily available air-breathing turbine instead of a helium turbine or other closed loop design.

At the site, the reactor pressure vessel (RPV) will be installed underground in a concrete containment structure that includes a heat transfer path to the surrounding ground layer to provide a passive path for the management of the operating heat load and for reactor decay heat following shutdown. In addition, systems, structures and components which perform safety functions for the plant will be installed underground. The actual depth of the plant will be set based on safety and security requirements as well as on the site conditions.

The reactor is designed to operate in two normal states - load following and shutdown. The plant is designed to be fully automatic and operated locally by the advanced StarCore HyperVector Control System,

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2 AREVA INC, Lynchburg, Virginia, USA

with three satellite links to a remote real-time monitoring and intervention system located at StarCore Central Operations. The only on-site staff are those required for routine maintenance, materials and supplies.

The StarCore units are available in various configurations that will be tailored to the client's requirements. The base case reactor design produces 10 MWe and 15 MWth, where the thermal energy could be used for steam or district heating or other purposes. If less electrical power is required, then more energy in the form of shaft horsepower, steam or hot air can be provided. The standard reactor plant design consists of two reactors integrated into a single building, but for larger applications up to six units can be integrated into a single reactor plant in a three-legged star arrangement. This results in a maximum of 60 MWe and 90 MWth for a six-unit plant, with many possible variations trading off electrical and thermal energy.

Each reactor unit is self-contained, sharing only systems, structures and components that do not have safety functions. The balance of the facility is optimized to share systems, structures and components. Many configurations will be available to meet customer requirements, including, for example, elimination of one or both turbines to maximize thermal energy. The design life of the plant is 25 years, with the reactors being refueled at site every five years.

The following sections go into more detail on the Nuclear Engineering, Energy Transfer Systems, Balance of Plant, and Control Systems.

2. Nuclear Engineering

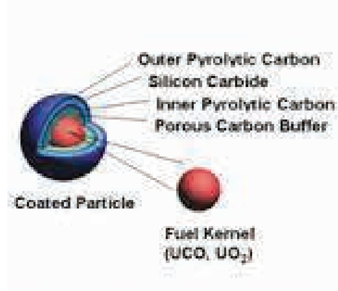
2.1 TRISO Fuel

In the TRISO fuelled reactor 0.92 mm TRISO microspheres are formed into fuel compacts for use in the reactor core. TRISO fuel is formed from small spherical granules of enriched uranium, which are then coated with a layer of porous carbon, a layer of extremely hard pyrolytic carbon, a layer of silicon carbide, and a further layer of pyrolytic carbon. The final microsphere is 0.92 mm in diameter and provides a containment structure for all the fission products that are formed. The internal pressure caused by the decay products and gaseous isotopes is around 5 MPa, and although the fuel structure is strong enough to retain this internal pressure, the counter-pressure of the primary coolant system will also cause a positive pressure gradient towards the inside of the TRISO microsphere thus providing an additional level of security.

These photos show the microspheres and the compacts into which they are made. (Artwork courtesy of INL and General Atomics)

StarCore intends to base the TRISO fuel specification on the fuel that is currently being qualified by in-reactor testing at INL, and will set the level of

TRISO Microsphere



Microspheres & Compacts

enrichment as needed to meet the overall requirements of the system, but expects it to fall between 16-19%.

2.2 Reactor Core Design

There have been two main TRISO core designs used over the years - the spherical 60 mm "pebble" used in the pebble bed designs and the prismatic designs, which consist of hexagonal graphite blocks with fuel compacts inserted in them. StarCore has decided to use the prismatic core design. In the prismatic design the core is made up of hexagonal graphite blocks that are 360 mm across the flats and 793 mm long. Cylindrical fuel compacts (26 mm diameter and 39 mm long) are inserted into holes drilled in the graphite blocks, and burnable poison elements will also be inserted as needed. The helium flow will be through vertical holes drilled in the blocks.

Graphite Fuel Block

The final design of the reactor core has not been completed, but initial neutronics models and performance assessment have been carried out at INL. The dimensions of the core will be adjusted during the modeling of the neutronics and the thermal hydraulics to produce the optimal results. The main core characteristics of the current design are shown in the table below.

Reactor Core and Fuel Properties	
Property	**Value**
Moderator	Graphite
Reactor Pressure Vessel Height	7.4 m
Reactor Pressure Vessel Diameter	2.6-3.0 m
Reactor Pressure Vessel Material	SA508/533
Reactor Cooling (Forced or Natural)	Forced
Coolant Type	Helium gas
Number of Control Rod Drive Mechanisms (CRDMs)	12 (6 in each of 2 systems)
Fuel Type	TRISO (coated particles of UCO)
Graphite Reflector: Radial / Top / Bottom	29 cm / 50 cm / 50 cm
Maximum Fuel Burnup: GWd/t / Percent	60 GWd/t / 6 %
Fuel Enrichment	16-19 wt% U-235/U
Fueled Core Diameter / Height	186 cm / 400 cm
Number of Fuel Blocks: (1 + 6 + 12) x 5	95
Fuel Cycle	60 months

The reactivity control mechanism is a reflector/absorber in the form of a cylinder running the length of the core, split into two semi-circular regions, with one being static and the other capable of rotating through 180 degrees to present either a reflective or absorptive surface to the main neutron flux. The closed (reflective) position of the cylinders is controlled by a stop, the position of which can be changed as required. It is intended that these cylinders will not be fully closed (100% reflective) when the reactor is first commissioned, and that the closed stop position will be changed as the core ages to allow the reactivity margin to be maintained over the life of the core.

There are two separate sets of six control cylinders, with each set using a different control mechanism design to provide operational redundancy. Each set can shut down the core even if the other set does not deploy. The reactivity control cylinders are controlled by means of helium powered mechanical motors, so that if the helium system loses integrity and the pressure falls the cylinders will automatically fail to the fully open (absorptive) position.

2.3 Reactor Safety

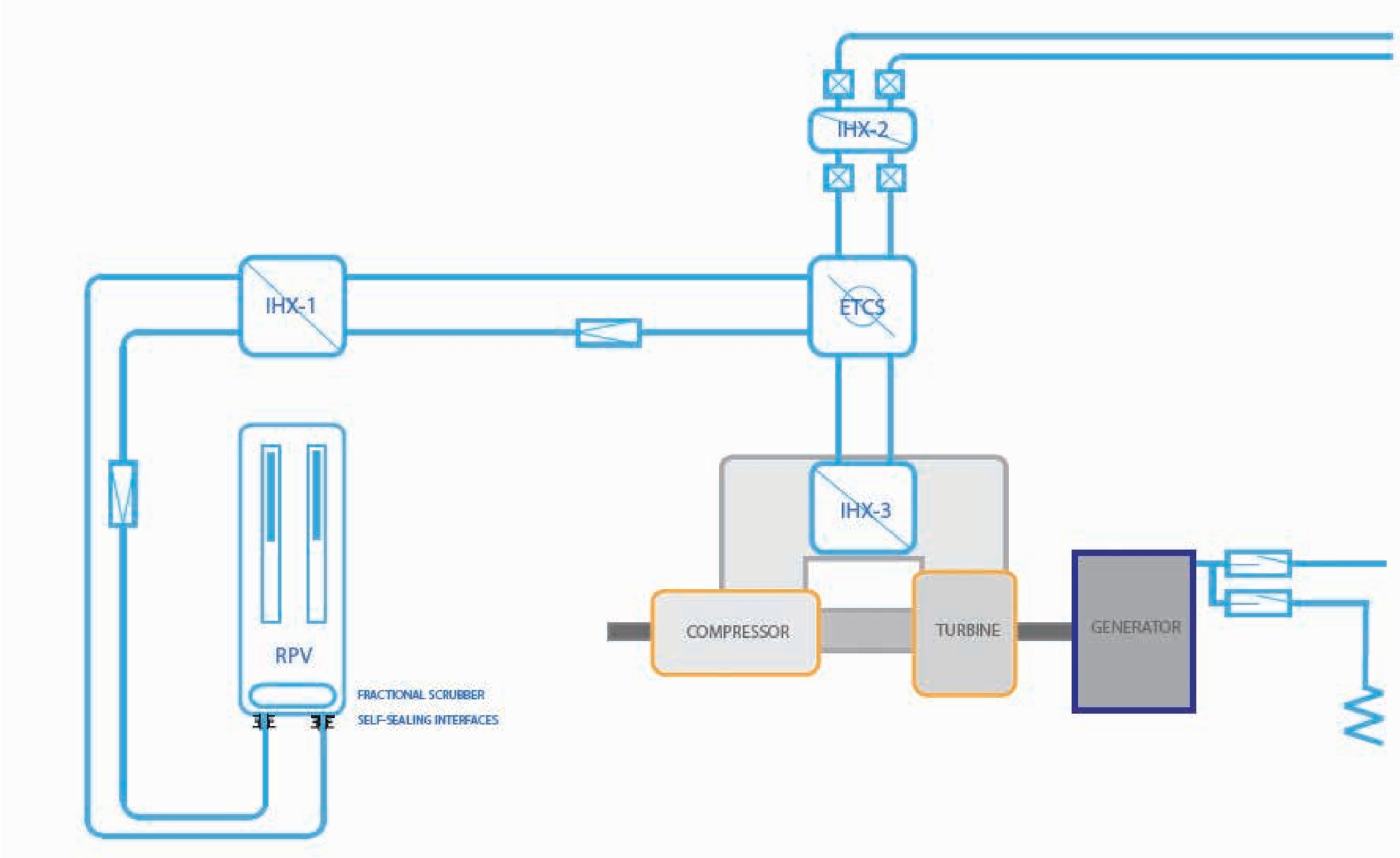
The TRISO fuel exhibits a very strong negative temperature coefficient. As the fuel temperature increases the neutron energy also increases; this effect reduces the neutron cross sections and lowers the number of fissions and thus the power level. The result of removing all reactivity controls and shutting off the primary and secondary cooling systems in the Chinese HTR-10 test reactor was a thermal output that peaked at around 225% as the temperature increased, and then dropped to an extremely low level after about 50 seconds [4]. After around 55 minutes the core cooled off enough for the output to rise again, and then it stabilized after several cycles to around 10% of the base thermal output level. This output will (obviously) automatically follow the thermal dissipation of the RPV; the greater the thermal dissipation the greater the core output. StarCore expects the thermal output when the core is stable to be around 600 kWth.

3. Energy Transfer Systems

The system schematic for the plant is presented below; it shows the energy transfer path as well as the main components.

There are two main energy transfer stages, Energy Transfer System 1 (ETS-1) and ETS-2. ETS-1 uses helium pressurized at 7.4 MPa and transfers the thermal energy from the RPV to the ETS-2 through the intermediate heat exchanger, IHX-1. It also has a helium circulator. The output temperature of the RPV is (nominally) 850 C. The ETS-2 system will operate at a lower temperature due to energy loss in the ETS-1 and IHX systems; it uses nitrogen pressurized at 6.8 MPa to provide a nominal pressure balance across

Schematic of Reactor, ETS-1 and ETS-2



the IHX-1 to reduce any tendency for helium leaks in this critical area. The slight pressure gradient is established from ETS-1 to ETS-2 so that any gas migration will be in the direction of helium-to-nitrogen, and thus avoid any chemical contamination on the ETS-1.

The ETS-1 forms the secondary pressure boundary of the reactor and associated first stage energy (heat) transfer system, with the TRISO microsphere forming the first pressure boundary and the underground silo forming the third boundary. ETS-1 includes the RPV, reactivity control systems, helium transfer piping, IHX-1, and helium circulator.

3.1 Helium Circulator

The helium circulator is placed in the cold piping leg of ETS-1. It is planned that the circulator will use one of the available tested designs, either submerged in the primary coolant with active magnetic bearings, foil bearings or operated outside of the pressure boundary with a drive shaft penetrating it combined with a dry gas seal design.

3.2 Intermediate Heat Exchanger-1

The intermediate heat exchanger design has not been chosen at this time. As a part of the NGNP design, INL produced a study [8] of the various technologies available for a high- temperature helium-helium intermediate heat exchanger. This study considered a number of designs, including a plate machined heat exchanger, plate fin heat exchanger, and the plate stamped heat exchanger (all of which are compact heat exchanger designs). In addition, the standard shell and tube heat exchanger is a low-risk, robust, common industrial design.

StarCore will be evaluating these competing designs as part of the design concept validation phase, with a compact heat exchanger the preferred design.

4. Balance of Plant

The two main energy transfer systems are summarized above in Section 3. This section discusses ETS-2, the power conversion unit, ancillary outputs and civil design.

4.1 Energy Transfer System 2

The ETS-2 nitrogen system transfers the energy to the energy transfer control system that directs the high temperature nitrogen to either the IHX-3 heat exchanger in the external combustion turbine, or the IHX-2 heat exchanger that can be used for load following.

4.2 Power Conversion Unit

The base case power conversion unit is an axial flow aero-derivative turbine converted from an external combustion design, with a heat exchanger (IHX-3) located in the internal gas path where the fuel burner cans would normally be located. Other turbo-machinery is also being considered, including a hybrid marine turbo-charger and a compressor-expander unit of the type used in heat process plants. No decisions have been taken at this time about single spool or two spool designs; two spool units are more efficient, flexible and provide greater load swing capabilities, but they must be protected from spool runaway in the event of sudden load dumps.

Various load following arrangements are being considered, including diverting the energy input from the power conversion turbine to a cogeneration super-heated steam output via IHX-2. The IHX-2 unit is rated at 5 MWt so it can provide an instantaneous plus 2 or minus 3 MWt load swing from the nominal output. This unit is kept at the nominal 2 MWt steam output. Also being considered are bypassing gas flow around the turbine, and incorporating a flywheel in the system.

4.3 Ancillary Outputs

There are a number of ancillary outputs planned for the StarCore plants; these include super- heated steam (450 C nominal), high temperature air (400 C nominal) from the turbine exhausts) and shaft horsepower. These outputs will be tailored to the application and could be used for a variety of purposes including potable water production, space heating, the provision of compressed air and district heating.

4.4 Civil Design

The conceptual design of the plant is shown below. The main elements of the design are intended to provide passive safety, and to prevent any unauthorized access or intentional damage to the plant occurring without the need to provide overt security fences or onsite personnel.

The site is 250 m in diameter, and is graded to show that the property belongs to StarCore while allowing free access to the facility. The building has two floors at the personnel entrance on the right and a single two-story turbine room on the left. Accommodation is provided for full time occupation by four personnel on the second floor, although not needed for the operation of the plant, which is fully automatic. It is expected that there will be two full time personnel on the site. Two backup diesel generators of 500 kW each are provided, and there are two-story spaces for secondary output processes. The interior has a hardened internal citadel to keep unauthorized personnel out of the turbine and machinery rooms, and access to these spaces is by means of double-door personnel locks. There are emergency exits located on each floor, and the whole building and silos are constructed of high performance concrete with varying strengths between 30,000 and 70,000 psi. The building and silos are made from pre-fabricated concrete sections that are assembled on site after foundations are poured.

Conceptual Design of Reactor Plant

5. Control Systems

Most nuclear plant control systems today rely on operators to determine the correct course of action in complex circumstances. This is not practical for remote locations. StarCore's control technology will provide on-site automatic control with full-time monitoring and intervention capability from StarCore Central by satellite. Only maintenance and power distribution engineers will be on-site. Local control will be provided for start-up, monitoring and shutdown during plant qualification and local emergency conditions. The StarCore Control System is secure and is ideal for remote sites.

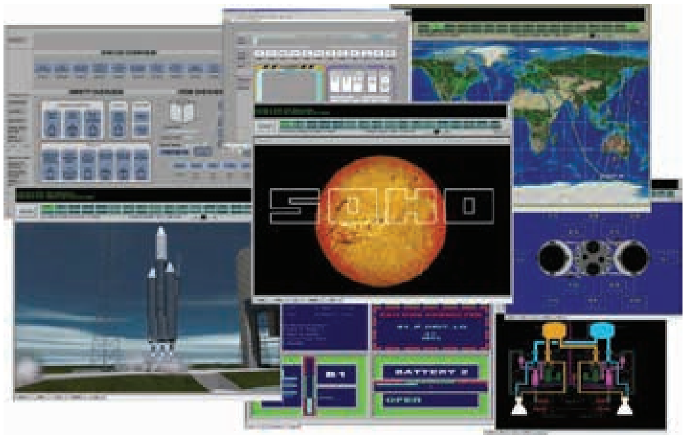
5.1 StarCore HyperVector Automated Control

StarCore will install an advanced, fully automated HyperVector Control System previously used in many safety-critical aerospace systems. There are many benefits that this control system technology brings, including: automatic failure prediction for every system or component in an arbitrarily complex application, alarms that uniquely identify any specific failures that have occurred or are predicted, controls that prevent wrong commands or actions ever being taken, and automatic responses to arbitrarily complex failures.

The system is named after the manifolds in state space that define the operational limits of the systems; these are represented by n-vectors, or HyperVectors, defined as (complex) data in the imaginary plane. The states are defined for every component in the plant, with each component having a state topology that reflects system operations. They also use the state loci and rate to calculate time to state boundary, and thus predict - in real time – time to failure of every component in the system.

Some of the systems on which HyperVector control has been deployed are shown in the figure below; the Solar Deep Space Observatory, SOHO; Titan II; Delta IV; Nuclear Waste Management and other systems can be seen.

Typical Systems Using Hyper Vector Control Systems



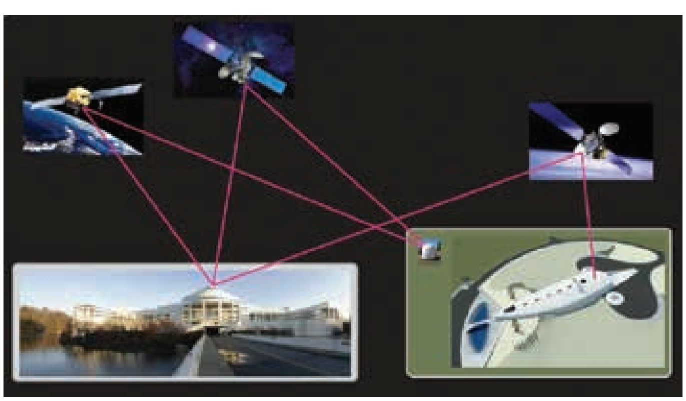
5.2 Safety and Security

The system is a model-driven, real-time, component-based, software architecture that features a triple-redundant backbone with real-time error monitoring and voting. It uses the Security Enhanced Linux operating system for all main processing and control, a two-bus separate system for operator user Interfaces, and has triple-redundant embedded field-programmable gate arrays for real time processing of critical safety functions. This design makes the system immune to virus and other malicious software. It also offers several important benefits, including the ability to bring additional functionality or plug-in modules without disturbing the certification or stability of the deployed systems. The complete cyber-security design is being developed and coordinated with the Canadian Standards Association (CSA) under CSA Standard N290.7. StarCore is a member of the CSA standards committees.

5.3 Architecture

The StarCore HyperVector I&C Control System is three-bus component-based design; it has a total of nine independent processors for each reactor/turbine unit. Three of these are installed in the silos themselves; these safety systems are logically and physically separated from the remainder of the system. There are three general purpose processors in the remote plant; and three more are installed in StarCore Central Control, connected by three, independent, satellite links, each with triple redundancy. The general arrangement of the satellite links is shown below. There is a main and backup full time 50 Mb/s link through two different geosynchronous (GEO) satellites that provide continuous coverage, and an emergency backup link through a low-earth (LEO) orbiting satellite. The GEO links use radomes at the StarCore site, while the LEO link uses an antenna embedded in the surface of the StarCore main building.

Satellite Links



The StarCore I&C technology also includes a "Keep Alive" signal, transmitted to a plant at pre-defined intervals. This sets a defined period at the end of which the plant will shut down if the next Keep Alive is not received. This feature clearly will not be appropriate for all plants but is available for remote installations that may present significant operational risks.

6. Conclusion

StarCore has made significant progress in developing a reactor plant that can be used at remote sites off-grid or at end-of-grid. Its power level has been designed to meet the requirements of these remote sites, whether they are mining sites, industrial sites or communities. The next steps in its development are the completion of the conceptual design and participation in a Vendor Design Review with the Canadian Nuclear Safety Commission.

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Commentary on Inhaled $^{239}PuO_2$ in Dogs – A Prophylaxis Against Lung Cancer?

by JERRY M. CUTTLER[1] and LUDWIG FEINENDEGEN[2]

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Abstract

Several studies on the effect of inhaled plutonium-dioxide particulates and the incidence of lung tumors in dogs reveal beneficial effects when the cumulative alpha-radiation dose is low. There is a threshold at an exposure level of about 100 cGy for excess tumor incidence and reduced lifespan. The observations conform to the expectations of the radiation hormesis dose-response model and contradict the predictions of the Linear No-Threshold (LNT) hypothesis. These studies suggest investigating the possibility of employing low-dose alpha-radiation, such as from $^{239}PuO_2$ inhalation, as a prophylaxis against lung cancer.

1. Introduction

Many studies are carried out on beagle dogs because they model humans. The authors of a study on inhaled $^{239}PuO_2$ particles in beagles, Fisher and Weller [1], identified the possibility of a beneficial health effect–lung tumor suppression at a low radiation dose. This was based on a statistical test they carried out "on the null hypothesis to determine the probability that the controls and the lowest dose groups have the same underlying probability of tumor incidence, and that tumor incidence is unrelated to dose (testing for a threshold effect)." Because of the infinitesimally small amount of plutoni 48 cGy. However, the observed data of 0 tumors in the 16 dogs in the 8 to 22 cGy range and 1 tumor in the 10 dogs in the 27 to 48 cGy range suggest a beneficial effect. Is there a scientific basis for this data to challenge the LNT model?

The overall shape of the dose-response data shown in [1], figures Fig. 1 to Fig. 4, is very non-linear. Furthermore, severe molecular damage, including many double-strand DNA breaks, occurs locally around each plutonium particle in tissue. These breaks are caused by the alpha radiation with its dense ionization, i.e., high LET, over a distance of several cell diameters. Since cancer is associated with DNA mutations, tumors are predicted at these locations. Considering the spontaneously- occurring lung tumors, it is quite surprising that only one tumor was observed among the 26 dogs that were exposed to cumulative lung absorbed doses in the range 8 to 48 cGy. At these doses all cells are hit at least once by an alpha-particle. [3] The data and the biology conform to the lack of increased lung cancer in people living in houses with elevated radon concentration [4] and contradict the LNT prediction that the probability of radiation-induced cancer is proportional to dose.

2. Adaptive Protection Systems

There is a large amount of data from a wide variety of medical treatments with radiation at doses below 100 cGy, including treatments for serious infections, and many radiobiological studies, all carried out over the past 120 years. These data show a remarkable effectiveness in healing. Moreover, even lower doses or lower level dose-rates, predominantly below 20 cGy, can up-regulate adaptive protection systems in terms of delayed and temporary detoxification, DNA-repair, and damage removal in various ways. [5] [6] Such exposures have been shown to remove spontaneously-occurring cancer cells induced by endogenous effects and also remove radiation- induced damage. For example, oncologist K. Sakamoto observed the total removal of tumors in all regions of the body, probably by induction of protective mechanisms, of a patient with advanced ovarian cancer, after treatment with 15 whole-body doses of only 10 cGy x-rays, over a 5 week period. [7]

The biological phenomenon that results from adaptive protection is radiation hormesis. [8] [9] [10] This model predicts a reduction in the overall incidence of lung tumors, as a consequence of stimulation of protection by low level radiation. The Fisher and Weller data [1] comply with these expectations. In the lowest range, from 8 to 22 cGy, no tumors were observed. Fig. 3 indicates a strong rise in the incidence of tumors, as the cumulative dose increases, which flattens starting at about 500 cGy. As shown in Figure 1, the NOAEL (no observed adverse effects level) dose is about 100 cGy.[1] (Radiation pneumonitis is the cause of death

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1 For miners, a radon exposure of 500 working level months (WLM) gives a dose 100 cGy, which is the threshold dose for alpha-radiation induced lung tumors. A house with a radon level of 100 Bq/m^3 gives an accumulated annual dose of 0.4 to 0.7 WLM. [22] Therefore, a person living in a house with a radon level of 1000 Bq/m^3 would receive the threshold dose of 100 cGy in 500/5.5 = 91 years.

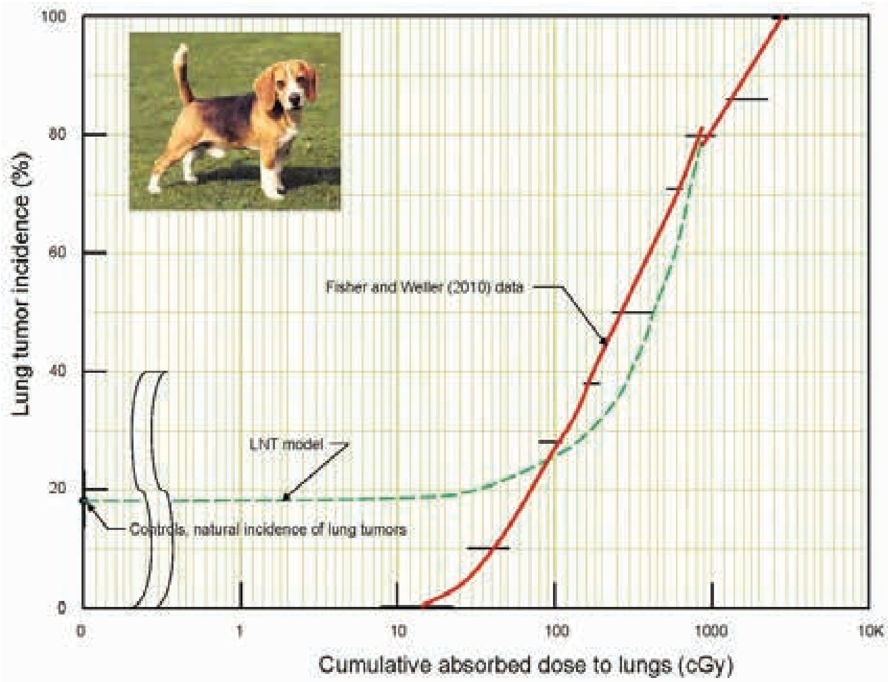

Figure 1: Lung tumor incidence vs. absorbed dose in beagle dogs that inhaled $^{239}PuO_2$ (adapted from Fig. 3 and Fig. 4 of reference [1])

following exposures above 3000 cGy.)

In challenging the LNT theory, Fisher and Weller also point to the measured lifespan dose-response relationship in Fig. 5 for dogs that inhaled $^{239}PuO_2$. [1] The lifespan appears to increase significantly from about 5000 to 6000 days, when the dose rate is raised by a factor of 3.6 from 0.0055 to 0.020 cGy per day. The threshold (NOAEL) for a return to 5000 days is ˜0.030 cGy per day or 11 cGy per year (155 cGy lifetime). The data in Fig. 4 and 5 point to a beneficial effect after a low dose and contradict the LNT prediction of an excess risk of late health effects in proportion to the radiation dose.

3. Biological Basis for Radiation Hormesis

Radiation hormesis theory [10] is based on the following biological facts:

1. The DNA molecules in all organisms are being damaged at a relatively high rate by endogenous processes, which include temperature, reactive oxygen species and other agents. Damage to DNA, cells and tissues/organs also occurs due to external causes, such as thermal burns, physical injuries, infectious pathogens, ingestion of chemical substances, etc. The rate of damage to DNA due to average background radiation, including double strand breaks, is relatively negligible even if the quality of radiogenic DNA damage is on average more severe than endogenous DNA damage. [11]
2. Biological organisms have very powerful protection systems that prevent, repair and remove DNA damage, replace damaged cells and tissues, cure infections and endeavour to restore health. The overall ability of these systems to enable individuals to survive even severe stresses and the many daunting challenges of life is very impressive. There are immediately- acting protection systems and adaptive systems responding to internal signals under genetic control (more than 150 genes involved) with a delay of up to hours and lasting from days to months and even years. These responses depend on the sensitivity of the affected system with various thresholds. With increasing impact of stressors, adaptive protections tend to fail and give way to damage. The eventually resulting damage, such as obvious cancer, is then the difference between prevention of damage from different sources by adaptive protection, induced by low dose radiation, and damage caused by the primary radiation impact.

With increasing acute radiation doses or dose rates, different genes are activated at different thresholds [12] and "turn on" appropriate adaptive protection systems, which act against the consequences of harmful agents, regardless of their sources, to restore health. When the radiation dose or dose rate increases beyond the ranges of response sensitivity of the impacted system, protection diminishes and eventually fails and the response of the organism to the exposure moves into the range of harmful effects. Still, when this occurs, other mechanisms are activated by other genes to mitigate the harm and improve the probability of survival, for instance, by removal of damaged cells and structural replacement with functional restoration.

4. Radio-toxicity of Inhaled $^{239}PuO_2$

A note by Simmons and Richards [13] refers to the work by Muggenburg et al. [14] on radio- toxicity of inhaled $^{239}PuO_2$, plotting the incidence of lung tumors at low doses and observing an apparent threshold at approximately 100 cGy, which is consistent with the data of Fisher and Weller [1]. After assessing strong evidence on the basis of microdosimetric analysis and results of other studies, they concluded that there is no reduction in lifespan at lung doses below about 100 cGy and no significant increase in incidence of lung tumors at lung doses below 62 cGy. All of the studies "show that there is a threshold in the region of about 100 cGy in the lung dose required to induce cancer in that organ." [13]

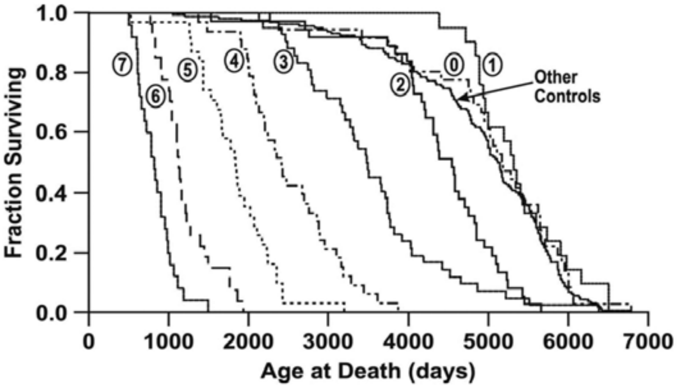

Figure 2: Survival curves for dogs that inhaled graded activity levels of $^{239}PuO_2$ (from Muggenburg et al. [14], with permission from Radiation Research)

Table 1: Normalized lifespan of beagle dogs following $^{239}PuO_2$ inhalation.

Exposure Level	Initial Lung Burden kBq/kg	Lung Dose to Death cGy	Age to Death days	Normalized Lifespan 50% mortality
Controls	0	0	5150	1.00
1	0.16	160	5316	1.03
2	0.63	620	4526	0.88
3	1.6	1300	3482	0.68
4	3.7	2400	2421	0.47
5	6.4	3500	1842	0.36
6	14	4500	1122	0.22
7	29	5900	807	0.16

The study by Muggenburg et al. [14] was designed to measure the lifespan health effects of different degrees of alpha-particle dose non-uniformity in the lung. The lowest exposure level was an initial lung burden of 0.16 kBq/kg, which corresponds to an accumulated 160 cGy lung dose to death. The dose range is well above the level at which lung tumor inhibition could be expected, based on the study by Fisher and Weller [1]. However, the data in Fig. 4 in the paper by Muggenberg et al. [14] on the survival of dogs present evidence of a possible beneficial health effect for low-level inhalation. This figure is reproduced below as Figure 2. Table 1 and Figure 3, derived from this figure, reveal a clear threshold above which inhalation of plutonium-dioxide leads to reduced lifespan. It also suggests the possibility of an extended lifespan due to a lower incidence of spontaneously-occurring lung cancer.

5. Inhaled Beta-Gamma Emitting Radionuclides

A review was carried out recently on dogs that inhaled ^{90}Sr, ^{144}Ce, ^{91}Y and ^{90}Y, imbedded in an insol-

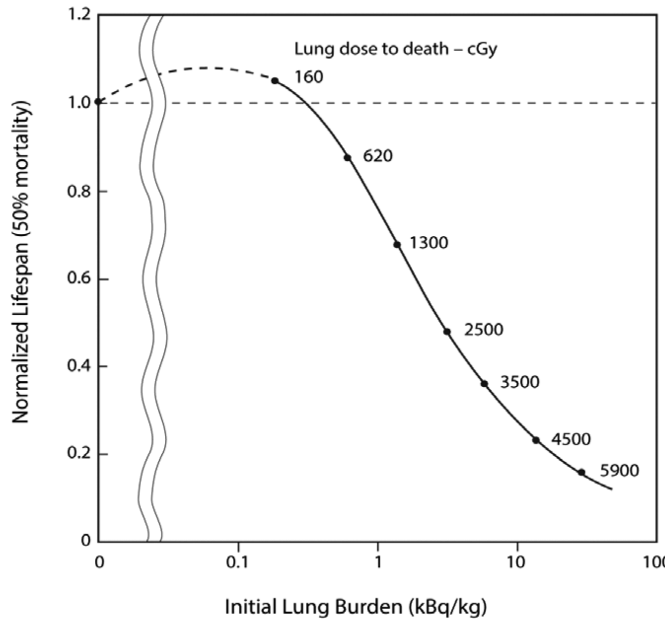

Figure 3: Normalized lifespan of beagle dogs following $^{239}PuO_2$ inhalation.

uble, fused-clay matrix. [15] The lungs, heart and nearby lymph nodes were the targets of the chronic low-LET radiation dose. Cumulative doses to the lungs ranged from zero up to 10^5 cGy, and the initial dose rates ranged from zero up to 7000 cGy per day. In the high-dose region, cancer increased with radiation dose to a very high frequency. However, there was no evidence of radiation-induced cancer when the doses were below 2500 cGy. This is apparent in the data in Fig. 6 in the paper by Brooks et al. [15]. "The 53 dogs in the control group had a total of 8 lung cancers, for a baseline incidence of 15%." "In the 80 exposed dogs that received doses less than 25 Gy, there were a total of 6 lung tumors observed." Total cancer frequency in the control dogs was about 50% (26 cancers in 53 dogs). In the group of 20 dogs in lowest dose group (50 cGy), there were only 3 total cancers observed–significantly decreased relative to the controls.

6. Conclusion

The 50-year study of plutonium exposure to the Manhattan Project plutonium workers [16] suggested beneficial health effects. There was no evidence that the incidence of lung cancer was elevated, as would be expected from the exposures received, based on the LNT hypothesis. Furthermore, the 30-year follow-up of a plutonium-americium inhalation exposure [17], with a committed effective dose of the order of 100 cSv, shows no evidence of lung cancer; the subject is in good health.

All medical treatments with low radiation were discontinued following the 1956 recommendation of the National Academy of Science (NAS) Committee on the

Biological Effects of Atomic Radiation (BEAR). [18] It recommended the LNT instead of the threshold dose-response model to evaluate the risk of genetic mutations from ionizing radiation. This led to the enormous radiation scare that links any exposure to a risk of cancer. After Calabrese prepared several carefully researched papers on the history of the LNT model, he reviewed [19] [20] the archives of the BEAR committee and determined that the LNT concept for assessing genetic risk due to radiation did not comply with data available at that time and that the LNT model was a construct.

Lung cancer is the leading cancer killer in the United States. The studies on inhaled plutonium- dioxide suggest that the incidence of spontaneously-occurring lung tumors could be significantly reduced by low-dose alpha-radiation, such as from a single inhalation of $^{239}PuO_2$, as a prophylaxis. Because the amount of plutonium is infinitesimally small, plutonium toxicity is of no concern in this context. Pollycove [21] has summarized the rationale and radiobiological basis of low-dose irradiation for the prevention and therapy of cancer. This and many other medical applications of low-dose radiation treatment should be investigated.

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(Compiled by Colin Hunt from open sources)

Canadian Nuclear Companies Complete Trade Mission to the UK and Romania

More than a dozen Canadian nuclear suppliers joined the Organization of Canadian Nuclear Industries (OCI) on six day trade mission to the UK and Romania last week. The highlight of the UK leg of the Trade Mission was the first "Canada - UK Nuclear Suppliers Industry Day" hosted by the Canadian High Commission at Canada House in central London on June 29 at which Canadian suppliers shared their experience and interest in collaboration with more than 45 representatives of the UK's nuclear industry.

An important and timely focus of the Industry Day was on SNC-Lavalin-Candu's CANMOX™ proposal for the safe and efficient reuse of the UK's civil plutonium and recovered uranium stockpiles. The CANMOX proposal, based on the construction of four Enhanced CANDU6 reactors in the UK, would have the potential to power more than 500,000 UK homes for at least 60 years while providing long term, high quality employment opportunities for both Canadian and UK workers. "OCI companies are committed to working with the UK nuclear supply chain on the CANMOX solution making this a true "UK-Canada project" said OCI President Dr. Ron Oberth.

The Industry Day was kicked off with the signing of a UK-Canada MOU on enhanced collaboration among Canadian and UK government agencies and nuclear companies in the field of civil nuclear energy. This MOU, signed by Canada's High Commissioner Gordon Campbell and Lee McDonough, Director, Office of Nuclear Development for the UK Department of Climate Change, is a key step in enabling the CANMOX project and other projects related to the provision of safe, reliable and affordable nuclear power.

The OCI-led Trade Mission carried on to Bucharest, Romania where the Canadian nuclear team was invited to a July 1 Canada Day Celebration hosted by the Canadian Embassy. The highlight of the Romanian leg of the Trade Mission was the Canada-Romania Cernavoda 3/4 Supply Chain Partnering Workshop on July 2 organized by OCI and its Romanian counterpart ROMATOM (Romanian Atomic Forum Association). The Partnering Workshop included an update on the planned Cernavoda 3/4 CANDU Project as well as presentations by Canadian and Romanian nuclear suppliers on their capabilities

Canadian High Commissioner Gordon Campbell and Lee McDonough, UK Nuclear Development.

OCI President Ron Oberth and ROMATOM President Nela Rotaru sign an MOU regarding Cernavoda 3 and 4.

and experience along with discussions on their mutual interest in collaborating on the Project. The Trade Mission included visits to Romanian manufacturing facilities that will lead to partnering among Canadian and Romanian nuclear suppliers.

At the start of the Workshop OCI President Dr. Ron Oberth and Dr. Nelu Rotaru, President of ROMATOM, signed an MOU that outlines several ways that OCI and ROMATOM will work together in support of the Cernavoda 3&4 Project and in identifying opportunities on other nuclear projects in Canada and other countries on which OCI and ROMATOM companies can cooperate. "OCI celebrates this MOU signing and looks forward to building a strong working relationship with the Romanian nuclear supplier community in ensuring that the planned Cernavoda 3&4 project will be completed on budget and on schedule and will create quality jobs in Romania and Canada" said OCI President Dr. Ron Oberth.

The combined UK/Romania Trade Mission was supported by co-funding from Global Opportunities for Associations" (GOA) program through which the Foreign Affairs, Trade and Development Canada (DFATD) encourages and supports trade associations in taking member companies into promising export markets.

Organization of Canadian Nuclear Industries (OCI) is an association of more than 180 Canadian suppliers to the nuclear industry that employ more than 12,000 highly skilled and specialized engineers, technologists and trades people. OCI companies design reactors, manufacture major equipment and components, and provide engineering services and support to CANDU nuclear power plants in Canada and to CANDU and Light Water Reactor (LWR) plants in offshore markets.

CNSC Renews Bruce Power Operating Licence

The Canadian Nuclear Safety Commission (CNSC) renewed the operating licence of the Bruce A and B nuclear power stations in a combined operating licence for a five-year term on May 28, 2015.

The CNSC issued its detailed record of proceedings including its reasons for its decision on July 9. The original application was filed in October 2103, and it was continued by two periods of public hearings on February 5 and April 13-15, 2015.

The CNSC also authorized Bruce Power to operate the reactors to a maximum of 247,000 hours of equivalent full power hours. This was an extension of its original limit of 210,000 hours.

The Bruce operating licences had originally been scheduled to expire in October 2014. However earlier in the year, the CNSC granted a short extension to the existing licences and agreed to postpone the public hearings until early 2015. This postponement would in the view of the CNSC allow for a more meaningful public hearing.

The CNSC provided up to $75,000 in funding for approved intervenors. The Canadian Nuclear Society (CNS) was one of 10 intervenors approved for funding. The CNS gave its presentation to the CNSC on April 14. The intervenors included then-President Jacques Plourde, Secretary Colin Hunt, and Council Member and a past president John Roberts.

Mr. Roberts also provided a submission on his own behalf regarding the importance of hydrazine to the Bruce reactors' chemistry.

Federal Government Selects Management Group for Canadian Nuclear Laboratories

NRCAN Minister the Hon. Greg Rickford announced on June 26, 2015 that the government had selected the Canadian National Energy Alliance (CNEA) as the preferred bidder to manage and operate Canadian Nuclear Laboratories (CNL).

The CNEA consists of five member companies: CH2M HILL Canada Limited, Fluor Government Group – Canada Inc., EnergySolutions Canada Group LTD., SNC-Lavalin Inc., and Rolls-Royce Civil Nuclear Canada Ltd. CNEA was selected through a competitive bidding process with several other groups in contention.

The federal government is now in the process of finalizing the management contract for CNL. CNL will continue with its core mandate on waste and decommissioning, nuclear expertise to support federal government responsibilities, and to provide research and other services to users of CNL facilities and personnel on commercial terms.

The restructuring of Atomic Energy of Canada Limited (AECL) is one of several measures the government has taken to support Canada's nuclear industry. Others include $325 million in research infrastructure at CNL, modernizing nuclear liability legislation and opening access to trade opportunities for nuclear energy in China and India.

Cameco Uranium Operations Affected by Northern Forest Fires

Cameco Corporation reported on July 9 that northern forest fires in the province of Saskatchewan have affected temporarily its uranium mining shipments. Production of uranium at its McArthur River, Key

Lake, Cigar Lake and Rabbit Lake uranium mines has not been affected, and none of its operations are directly threatened by the fires.

Cameco has implemented additional measures to protect the health and safety of people and the environment at its facilities, and it is providing assistance to northern communities in firefighting and supporting evacuees.

However, road closures and flight restrictions are creating logistical problems in northern Saskatchewan. There are only two hard surfaced roads connecting Cameco's northern operations with southern Saskatchewan. To limit non-essential traffic, Cameco has suspended temporarily packaged shipments from its milling facilities. The roads have occasionally been closed because of poor visibility or fire proximity.

Despite the extensive forest fires in Saskatchewan this summer, Cameco expects to meet its 2015 production target of 25.3 to 26.3 million pounds of uranium and its sales target of 31 to 33 million pounds.

Joint Review Panel Recommends Bruce DGR Site

The Joint Review Panel on May 6, 2015 recommended to the federal government that it approve the proposed Deep Geologic Repository (DGR) for low and intermediate wastes.

In releasing its full report, the panel concluded that "the project is not likely to cause significant, adverse environmental effects."

The panel's recommendation comes after more than 14 years of study and consultation. The joint review panel conducted the most comprehensive and science-based review of nuclear waste storage in Canadian history. The report reflects the views of hundreds of Canadians and Americans.

The DGR will be designed to protect the environment of the Great Lakes. It will be located at the Bruce nuclear facility in Kincardine, Ontario. It will store safely more than 200,000 cubic metres of low and intermediate waste produced by 40 years of operations of Ontario's nuclear power stations. It will be located 680 metres below the surface in stable rock formations more than 450 million years old.

The federal Minister of the Environment will make the final decision on the DGR. Leona Aglukkaq has extended the deadline for comment to September 1, 2015. This means that no decision will be made until after this year's federal elections.

The joint review panel offered a number of recommendations in arriving at its conclusions. The panel report noted that it had considered in detail not just the impact of the DGR but its cumulative impact with other activities including non-nuclear ones in the region. It also noted that the Saugeen Nation had been consulted extensively during the planning and public hearing process.

The full panel report can be found here: http://www.ceaa-acee.gc.ca/050/documents/p17520/101595E.pdf

Ontario Government, OCI Lead Trade Mission to South Korea

The Organization of Canadian Nuclear Industries (OCI), in partnership with the Ontario Government, recently led a trade mission of 18 leading Canadian nuclear suppliers and industry partners to South Korea – one of the world's fastest growing nuclear markets and a nuclear partner of Canada for almost 40 years.

The trade mission delegation, including 10 CEO's of leading Ontario nuclear organizations, returned to Canada on May 2, 2015 after one week of meetings with various Korea nuclear companies and government agencies. An eye-catching Canadian/Ontario nuclear pavilion showcased the broad capabilities of the Canadian team at the 30th Annual Korea Atomic Power Conference in Seoul on April 28 and 29.

"This trade mission capitalized on the strong relationship that OCI formed with its counterpart Korean organization, Korea Atomic Industry Forum (KAIF), after signing an MOU of cooperation during the Pacific Basin Nuclear Conference in Vancouver in August of 2014" said OCI President Dr. Ron Oberth.

Ontario's Minister of Research and Innovation, Dr Reza Moridi, and Bob Delaney, Parliamentary Assistant to Minister of Energy Bob Chiarelli, played key roles on the trade mission by opening doors to South Korea government agencies and demonstrating their government's support for Ontario's nuclear supply chain at key events during the week-long trade mission. "Having government and industry leaders on the same team with common goals of exporting Canada's nuclear technologies, developing partnerships with other nuclear power countries and creating jobs in the province sends a strong message to customers that Ontario is open for business" added Dr. Oberth.

Several important agreements were signed during the trade mission. Two companies signed deals worth several millions of dollars for supply of reactor components and control systems for the CANDU units at Wolsong. Other nuclear suppliers in the delegation established relationships with South Korean customers and partners that will lead to orders for equipment and service in South Korea as well as in other nuclear markets to which South Korean companies are exporting. Bruce Power and Ontario Power Generation both announced signings of cooperation agreements (MOU's) with Korea Hydro and Nuclear Power Company (KHNP) on the sharing best practices for nuclear plant operations, for refurbishment projects, and for maintaining positive relationships with host communities. The CANDU Owners Group (COG), whose members are the owners of CANDU plants in seven countries, also concluded a multi-million dollar agreement for increased collaboration in research, development and implementation of projects to enhance nuclear safety and improve plant operation.

Bruce Power Launches Site Bus Tours for Summer of 2015

Bus tours at the Bruce Nuclear Power Development.

The Bruce Power Summer Bus Tours officially kicked off a noon today. Heather Poechman, Development Student, Community Relations provided the first guided tour on-site to a packed bus.

Tours run every Tuesday, Wednesday, and Thursday throughout July and August with three tours daily at 12, 1 and 2 p.m. The one-hour bus tour provides a unique opportunity to see both Bruce A and B generating stations, the historical Douglas Point generating station, Corporate Support Centre along with many other sight-seeing attractions.

Babcock & Wilcox Reorganizes

Babcock & Wilcox Company has reorganized its operations, spinning off its nuclear and fossil fuel operations into two separate companies. The decision was announced by its board of directors on June 9, 2015, effective July 1.

Its large plant in Cambridge, Ontario will be part of the nuclear operating company, henceforth known as BWXT Canada Ltd. It includes the company's nuclear power manufacturing, engineering and services business.

Work on fossil fuel components ceased in Cambridge in 2013, but its nuclear business has increased.

Canada Allows Majority Foreign Ownership in Uranium Mine

The government of Canada has made an exception to its rule requiring Canadian majority ownership in uranium mining with the Michelin project in Labrador. It will allow Australia's Palladin Energy Ltd. to keep its ownership intact.

The Michelin project is under development.

In making the decision on June 22, 2015, NRCan Minister Greg Rickford said that the normal pattern in Canada is for uranium mines to be majority-owned by Canadian companies, but that exceptions can be allowed if there is a lack of Canadian interest in a project.

The world's uranium industry has been suffering from depressed prices for uranium for several years. It is hoped that the Michelin decision will encourage more investment in Canada's uranium sector.

Kyushu Electric Starts Fuel Loading for Sendai 1

Kyushu Electric Power Company commenced loading fuel into its Sendai 1 power reactors on June 7, 2015. This makes it the first reactor to recommence operations in Japan since the earthquake at tsunami in 2011.

Sendai consists of two 890 MW PWR type reactors. The reactors were removed from service for inspections in May and September 2011, respectively. They have remained offline while Japan rebuilt its nuclear safety structure after the accident at Fukushima Daiichi. This work included creating a new independent nuclear safety regulator, the Nuclear Regulation Authority (NRA).

Restart of the Sendai reactors has been supported by the Kagoshima prefecture. Subject to NRA oversight, Sendai 1 could return to full power by September of this year, followed by Sendai 2 about two months later.

An additional 15 reactors in Japan are proceeding through the restart process. This process has been prioritized to return to service the most needed reactors first in those localities and prefectures most supportive of restart.

Turkish regulator issues preliminary licence for Akkuyu

Turkey's energy market regulatory authority (EPDK) has issued a preliminary licence for preliminary work at what is to be Turkey's first nuclear power plant at Akkuyu in Mersin Province. JSC Akkuyu NPP is the Russian-owned company responsible for the construction of the project.

When completed, Akkuyu is to consist of four AES-2006 PWR type reactors of 1200 MW each. The plant is being financed by Russia under a build-own-operate model. The intergovernmental model between Turkey and Russia was signed in 2010.

Construction is expected to begin in 2016. At this time, the first units at the plant are scheduled to start operations in 2023.

Ten German, Austrian Renewable Suppliers, Municipalities File Suit Over Hinkley Point C

A group of ten German and Austrian renewable energy suppliers and municipalities have filed suit against the European Commission's approval of state aid for the planned Hinkley Point C nuclear power plant in the United Kingdom.

The group, calling itself Action Alliance and headed by Greenpeace Energy alleges in their suit before the EU Court of Justice in Luxembourg that the proposed construction of the plant in Britain could affect German electricity prices by up to 12 per cent and distort competition. They further claim that any large scale expansion of nuclear "has a clearly negative effect on the market value of wind and solar". If the approval by the EC in October 2014 is allowed to stand, the Alliance claims it could set a precedent for future nuclear projects.

The Alliance commissioned a study which showed that nuclear power plants currently planned by six European member states could lower the wholesale price of electricity in Germany by as much as 11.8 per cent.

Hinkley Point C is the proposed site of two Areva EPR reactors. EDF Energy has yet to make a final investment decision on the project, but it has made significant commitments already in site preparation activities.

Grafenrheinfeld Ends Electricity Production

The single-unit Grafenrheinfeld nuclear reactor ended its electricity production permanently on June 27 after 33 years of operation. The German government had ordered the reactor to close by the end of 2015.

The reactor, a 1275 MW PWR, had operated for more than 33 years producing about 333 TWh over its lifetime. By itself, that's enough electricity to supply the whole of the German state of Bavaria for at least four years. And in doing so, the plant avoided the emissions of about 355 million tonnes of carbon dioxide. However, plant owner EOn said that the plant was no longer economic to operate because of the government's new tax on nuclear fuel. The German government imposed a fuel tax in 2010 of 145 Euros per gram of fissile nuclear fuel, yielding revenues of about 2.3 billion Euros annually. This was in addition to other taxes and levies on nuclear operators in Germany to subsidize renewables, and to provide a 0.9 cent/kWh tax after 2016 for funding a waste repository.

In 2010, the German government reached agreement with Germany's nuclear utilities over future operations. In exchange for continuing the fuel tax, reactors would have extensions to their future operations approved. Reactors built before 1980 would have eight-year operating licence extensions, while newer reactors would have 14-year extensions. All of this was swept aside after the 2011 earthquake and tsunami in Japan. All nuclear plants would be closed by 2022, with the eight oldest reactors closing immediately. However, the German government did not remove the fuel tax. Hence, EOn did not refuel Grafenrheinfeld in 2015, as the cost of the tax cannot be recouped before the final government-ordered shutdown at the end of this year.

Grafenrheinfeld - 460 (EOn).

Climate: 39 Nuclear Nuclear Associations Collaborate

During ICAPP *(International Congress on Advances on nuclear Power Plants)* in Nice, France, 39 nuclear societies, representing 50,000 scientists from 36 countries from all five continents jointly signed a declaration that presents their commitment to the fight against climate change.

The declaration is a major component of the "Nuclear for Climate" global initiative to achieve recognition that nuclear is a low-carbon energy that is part of the solution to fight climate change. In the summer of 2014, nuclear engineers and scientists launched this grassroots initiative.

Initially launched through the French Nuclear Society, the European Nuclear Society, and the American Nuclear Society, the presidents or representatives from the participating organizations gathered today to declare, *"We proudly believe that nuclear energy is a key part of the solution in the fight against climate change."*

The scientists and business leaders stressed that each country needs access to the widest possible portfolio of low-carbon technologies available, including nuclear energy, in order to reduce CO_2 emissions and meet other energy goals.

They call for the new UNFCCC (United Nations Framework Convention on Climate Change) Protocols to recognize nuclear energy as a low-carbon energy option, and to include it in its climate funding mechanisms, as is the case for all other low-carbon energy sources.

CNS news

CNS Membership appoints large, new Council for 2015-16

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 May 31, 2015. In total, 10 new members were appointed, bringing the total number on Council to 30 for the 2015-16 term.

The new members on Council include: John Cui, Jerry Cuttler, Peter Easton, Mark Haldane, Michael Ivanco, Nick Preston, Wei Shen, Keith Stratton, Ron Thomas and Don Wiles. Retiring from Council at the AGM were Adriaan Buijs, Emily Corcoran, Rudy Cronk, Jad Popovic, Aman Usmani, Pauline Watson and Sayed Zaidi. Returning to Council are: Parva Alavi, John Barrett, Fred Boyd, Ruxandra Dranga, Mohinder Grover, Tracy Lapping, Kris Mohan, Dorin Nichita, John Roberts, Ben Rouben, Nick Sion, Ken Smith, and Jeremy Whitlock.

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

In his final address to the Membership as President, Mr. Plourde noted that the CNS had met and overcome many obstacles during the past year. These included the loss of long-serving personnel to the CNS as well as the First Vice President appointed at last year's AGM. Mr. Paul Thompson of NB Power accepted the invitation to step into the role in his place. Also during the past term, Mr. Fred Boyd retired as Publisher of the CNS Bulletin, and Ms. Denise Rouben retired as CNS Office Manager. They were replaced by Mr. Colin Hunt and Mr. Bob O'Sullivan, respectively.

Reporting to the Membership, Mr. Plourde also noted that the CNS had succeeded in returning the Society to a budget surplus, reversing two years of revenue losses. This was achieved by a balance of increased revenues from the very good results of the Pacific Basin Nuclear Conference in Vancouver last August and targeted reduction in CNS expenditures.

Mr. Plourde noted that the CNS had maintained a strong program of conferences and courses during the past 12 months: CMC 2014, PBNC 2014, CANDU Fuel Technology Course, 3rd International Meeting on Small Reactors, and the CANDU Reactor Technology and Safety Course.

It should be noted that because of the resignation of Mr. Chugh last fall, Mr. Plourde was forced to assume the full burden of chairing the 2015 Annual Conference, a very large task which added greatly to the work of the President during the year.

In his address as incoming President, Mr. Thompson noted that CNS had a very busy schedule of conferences and courses for the next 12 months, seven events in total. He thanked the outgoing President

Passing the gavel – Jacques Plourde and Paul Thompson

2015-2016 President Paul Thompson and 2014-2015 President Jacques Plourde for his strong and effective leadership during the past year, and he thanked the outgoing Council members for their services.

The Annual Meeting approved a package of amendments to the CNS By-Laws. These amendments are primarily items missed during the passage of the By-Laws during the 2014 AGM. They include a definition of the Executive Committee and provisions for electronic voting for Council Members should an election be needed.

Mohamed Younis presented the Treasurer's Report and Financial Reviewer's Report to the membership. For the first time in three years, the CNS has reported a surplus for the year. The original budget for 2014 called for a small deficit of $9,000. However, the strong performance of PBNC last August combined with careful trimming of expenses resulted in a surplus of of approximately $60,000. This strong performance in part reverses the loss of $287,000 incurred over the years of 2012 and 2013. Mr. Younis indicated that the CNS currently expected a balanced budget for 2015.

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.

One interesting item during the AGM came in the form of two motions from the floor tabled by Dr. Peter Ottensmeyer. They called for the CNS to take steps to improve its system of presenting proceedings from its conferences. Dr. Ottensmeyer agreed to withdraw his motions in return for addressing the matter directly with the new Council at its next meeting. Incoming President Thompson indicated that the next Council would invite Dr. Ottensmeyer to attend to address the issue and authorize the preparation of an action plan.

This year's AGM was well attended with nearly 50 members in attendance in person or by proxy. The meeting was held in Saint John, NB at the beginning of the 2015 CNS Annual Conference.

News from Branches

BRUCE Branch – John Krane

The Bruce Branch participated in the Bluewater District Regional Science and Technology Fair held on **April 1st** and **April 8th** in Owen Sound Ontario.

Several members of the Bruce Branch were able to participate, judge and award prizes. Special recognition goes to Bill Moriarty (Bruce Branch Treasurer) who was able to participate on both days.

Two CNS prizes of $50 each were awarded and the Junior and Senior science fair recipients will be moving on to participate at the national science fair in Fredericton NB in May.

Good coverage, including a photo was published in the Owen Sound Sun Times newspaper.

GOLDEN HORSESHOE Branch (GHB) – David Girard

On **March 26th**, the Golden Horseshoe branch sent two judges to the **2015 Bay Area Science and Engineering fair** to award $400 in prizes on behalf of the Canadian Nuclear Society. These prizes were awarded to students for their projects on nuclear, energy or climate science.

The winning projects were:

- **Beans Under Radiation** - A study of how x-rays affect plant growth.
- **Polar Bears in Miami** - A study of climate change due to fossil fuel consumption.
- **Energy from Brown Water** - A machine built to create energy from waste water.
- **Fruits & Vegetables High in Volts - A study of how much energy is stored in produce.**

We congratulate all students for their wonderful projects and are proud to encourage potential future CNS members!

NEW BRUNSWICK Branch – Derek Mullin

As the incoming new Chair of the New Brunswick Branch, I would like to take this opportunity to gratefully acknowledge the many years of contribution by Mark McIntyre as Chair of the branch.

The New Brunswick branch is looking forward to the upcoming 35th Annual CNS Conference and 39th CNS/CNA Student Conference being held in Saint John, NB, from **May 31 to June 3, 2015**. As a conference organized by the CNS and Organization of Canadian Nuclear Industries (OCI) under the theme of "*Nuclear Innovation through Collaboration*", the technical and plenary programs will be very active as a forum for exchanging views, ideas and information related to nuclear science and technology.

OTTAWA Branch – Ken Kirkhope

Current Branch Executive

Ken Kirkhope	**Chair**
Mike Taylor	**Past Chair**
Fred Boyd	**Treasurer**
Jeet Khosla	**Secretary**
Jaroslav Pachner	Member at Large
Laurence Robataille	Webmaster
Ron Thomas	Member at Large

Meetings:

The Ottawa branch hosted an evening presentation by **Jacques Plourde**, current CNS President, on **April 7, 2015**. Jacques gave a very interesting and engaging presentation covering his **40 years in the nuclear field in Canada**, beginning as an attached student in the Reactor Control Branch of the Chalk River Nuclear Laboratories, through his 32 years in numerous roles at Ontario Hydro/Ontario Power Generation (OPG), through to his present role as a risk control consultant specializing in nuclear safety culture at the Nuclear Insurance Association of Canada (NIAC). Jacques also spoke of his vision of the CNS and coordination with the other nuclear societies and associations in Canada. His talk was very well received.

Education:

The CNS Ottawa branch was a sponsor and Fred Boyd participated as a judge at the **Ottawa Regional Science Fair**, on **March 28, 2015**. The CNS Ottawa Branch Special Award of $150 was presented to **Helen Engelhardt** of Broadview Public School for her project titled "**Residential Radon Reduction**".

SHERIDAN PARK Branch – Raj Jain

Raj Jain and Peter Schwanke participated at the Peel Region Science Fair 2015 as special judge. The following four students were awarded the special CNS award. The award is given to projects that investigate aspects of energy.

1. **Project: Effect of Water Pressure – Hydroelectricity**

School: Olive Grove School

Exhibitor: Mohammed Jan

2. **Project: Thermovoltaics**: Tailoring thermoelectric semiconductors to utilize electromagnetic radiation from the infrared spectrum to produce electricity.

School: Glenforest SS

Exhibitors: Karthik Prasad and Abhinav Boyed

3. **Project: Here Comes The Sun!** Maximizing Solar Panel Output Through Utilization of A Photovoltaic Concentrator

School: Mentor College

Exhibitor: Caleb Chadwick

4. **Project: The Fiber Tube!**

School: Earnscliffe Senior PS

Exhibitor: Markos Brown

TORONTO Branch – Andrew Ali

The University of Toronto Energy Fair, on **Friday, March 27th**, was a very successful event which was sponsored by the CNS. Our CNS Toronto Branch representative, **Eric Jelinski M. Eng. P. Eng. (Nuclear Engineering Instructor – University of Toronto)** was provided a spot at the reception table and was able to talk with everybody as they arrived to participate. He distributed about 100 of the CNA Nuclear Fact Books and talked with many students, other faculty, and some members of the public who had come in to participate. There was even one student from a local high school who dropped by to ask about studying nuclear next fall. The students were all very enthusiastic and are interested in the topic of nuclear energy.

The organizers, Anne Nasato et al, were very appreciative of the CNS sponsorship. It is worth noting that SPEA also sponsored the Energy Fair. The CNS logo was displayed on desktop computers in offices and libraries and on the brochure, so the nuclear message was very far reaching. Several professors from other disciplines of engineering also stopped by to network.

Stay tuned, the next major event is in the fall and is tentatively a panel discussion about energy. This should be an opportunity for some more involvement from the CNS.

WESTERN Branch – Jason Donev

The Western Branch is planning on holding its first ever '**book club**' event where a significant fraction of the branch reads the same book. The current intention is to read Half-Lives by Tammemagi and Jackson.

March 6th - Duane Bratt spoke in Regina (at the university) about the need for Small Modular Reactors in Saskatchewan.

Duane Pendergast arranged for presentations by **Dr. Allan Offenberger** titled; "**Fusion Energy: Status and Prospects**". Allan's presentations at the University of Lethbridge on **April 8**, and at the Southern Alberta Council on Public Affairs (SACPA) on **April 9** attracted about 150 participants in total. Audio and Power Points are posted on the SACPA website.

Aaron Hinman presented at the Earth Science for Society Exhibition to over a thousand Jr. High students.

Jason Donev participated with **Jeremy Whitlock** and **Doug Boreham** in putting on a nuclear 101 in Ottawa.

Jason Donev continues to work with the Nuclear Science Week committee and has started approaching Canadian institutions about doing events for the week.

Jacqueline Williams and Jason Donev are working with **Jingjing Wang** at CNL to try to create a simulation which helps teach about the importance of moderation in fission.

Sarah Ho has started a Western Branch Facebook group.

Jason Donev helped arrange for a talk on the history of fission given to a sold out audience (of over 300 people at the University of Calgary) to be taped. Hopefully it will be available by next report.

NUCLEAR FOR CLIMATE DECLARATION

Nuclear for CLIMATE

Nice – France
4 May, 2015

WE THE UNDERSIGNED,

Scientists, engineers, and professionals representing regional, national and international scientific societies, as well as numerous technical organizations dedicated to the development and peaceful use of nuclear technology,

Gathered here today in Nice - France

ACKNOWLEDGE the unequivocal conclusions reached by the majority of climatologists, as stated in the peer reviewed Fifth Assessment Report of the International Panel on Climate Change (IPCC) that "human activities have contributed to changes in the Earth's climate";

are HOPEFUL in regards to the outcomes of the Climate Change Conference that will take place in Paris in December 2015 - COP 21 (Conference of Parties);

COGNISANT of the fact that, according to OECD (Organisation for Economic Cooperation and Development), while the global population is expected to reach about 10 billion, with increasing development, electricity demand is currently on track to double by 2050;

SHARE the objective of limiting global warming to a maximum of 2°C by 2050, which will require, according to IPCC, 80% of electricity to come from low-carbon sources by that time (up from only 30% now);

are CONSCIOUS that this presents a massive challenge which will require the deployment of all available low-carbon technologies;

are CONVINCED that the world needs to take immediate steps to reduce greenhouse gas emissions, as a large share of the carbon budget has already been consumed, and that we cannot wait for future technologies to be ready for deployment before launching our decarbonisation efforts;

RECOGNIZE that nuclear energy is one of handful of options available at scale which can help to reduce energy related greenhouse gas emissions, and would emphasise that this view is shared by the OECD (Organisation for Economic Cooperation and Development) and IPCC.

Hereby declare that

WE PROUDLY BELIEVE THAT NUCLEAR ENERGY IS A KEY PART OF THE SOLUTION IN THE FIGHT AGAINST CLIMATE CHANGE

and BELIEVE that each country needs access to the widest possible portfolio of low-carbon technologies available, including nuclear energy, in order to reduce CO_2 emissions and meet other energy goals;

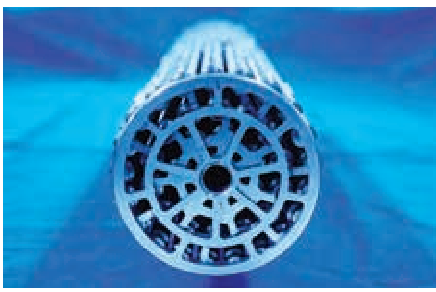
CALL FOR the new UNFCCC (United Nations Framework Convention on Climate Change) Protocols to recognize nuclear energy as a low-carbon energy option, and to include it in its climate funding mechanisms, as is the case for all other low-carbon energy sources.

have DECIDED to jointly sign this declaration and would like to bring it to the attention of decision-makers.

INCC 2015

International Nuclear Components Conference

November 1-4, 2015 · Delta Meadowvale Hotel and Conference Centre · Mississauga, Ontario, Canada



Photos © Canadian Nuclear Laboratories

Mississauga, Ontario will be the place to be for all interested in the hardware of nuclear power systems. For decades, the Canadian Nuclear Society has presented a series of conferences on steam generators and heat exchangers. INCC 2015 will continue that tradition, while expanding the scope of the conference to address other plant components.

This year's event will include topics of interest that are applicable to the new construction, ongoing maintenance and plant refurbishment of all types of power reactors.

The conference will highlight state-of-the-art technology and innovation, while keeping its strong links and importance to operating utilities and their ongoing needs.

Call for Abstracts of Presentations and Posters

The Technical Program Committee invites those involved with nuclear power plant major components to submit 300-word abstracts of proposed oral and poster presentations. Details are on the conference website.

Key features include:

- All major plant components: steam generators, heat exchangers, reactor components;
- Engineering design, fitness for service, life cycle and life extension;
- Science, technology and innovation within academic, nuclear research and engineering development sectors;
- Aspects of plant repair and refurbishment.

Who should attend:

All those involved with:

- Scientific research and technological innovation;
- Component manufacturers;
- Utility and contract engineering services;
- Government regulators;
- Students entering the nuclear industry.

Technical Scope

- Non-Destructive Evaluation
- Life extension, refurbishment and replacement (including, for the first time, craning and rigging)
- Life cycle management and asset management programs
- Nuclear plant chemistry
- Degradation of materials, component aging, and advanced inspection/evaluation techniques
- Fitness-for-service assessments
- Engineering Change Control (ECC)

Important Dates

Abstract Submission: March 25, 2015

Full Paper Submission: August 30, 2015

Early Bird Registration: September 25, 2015

For all conference details go to www.INCC2015.org

Calendar

2015

Aug. 9-13 — **17th International Conference on Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors**
Fairmont Chateau Laurier Hotel, Ottawa, ON
website: www.cns-snc.ca

Aug. 30-Sept. 5 — **Nuclear Reactor Thermal Hydraulics (NURETH-16)**
Chicago, USA
website: www.cns-snc.ca

Oct. 18-Oct. 20 — **7th International Conference on Simulation Methods in Nuclear Engineering**
Ottawa, ON
website: www.cns-snc.ca

Nov. 1-Nov. 4 — **International Nuclear Components Conference**
Mississauga, ON
website: www.cns-snc.ca

Obituary

Dr. Wallace (Wally) Kalechstein

Wally passed away 2015 April 26 as a result of an accident near Deep River, Ontario. We remember his wife, Joan, their son Simon, and daughter Sara.

Wally Kalechstein received his B.A.Sc (1972) in engineering science and Ph.D. in molecular physics (1978) from the University of Toronto. He was an NSERC Industrial Research Fellow at Electrohome Limited and Sentrol Limited from 1978 to 1980. He joined the Instrument Development Branch at the AECL Chalk River Laboratories as an R&D Scientist late in 1980.

Wally worked gained recognition in a number of diverse technology areas including:

- the development of second-generation infrared spectrophotometer heavy water monitors,
- techniques to optimize the performance of pressure sensors to measure internal fuel element pressure in coolant blowdown experiments at NRX and NRU,
- Safeguards bundle counter systems for the International Atomic Energy Agency (IAEA),
- development and application of the TACLES simulation codes for engineering and safety studies in support of the Slowpoke Demonstration Reactor and Slowpoke Energy System,
- reliability analysis of the control system for the MAPLE-X10 reactor, including the control software, and
- working on environmental qualification assessments for equipment for Pickering A Return to Service.

In the later stages of his career, Wally became an industry expert on emerging electromagnetic compatibility (EMC) standards, encompassing immunity and emissions concerns. His advice was sought regularly in regard to EMI immunity requirements for new product procurements and remediation of existing problems.

Wally had a great interest in the outdoors, including hiking, sailing, and cross country skiing. Those who took part with him tell of numerous adventures, many of them humourous.

We will remember Wally as a thoughtful, conscientious person who devoted his energies to his family, his community, and the nuclear industry.

[Complied by Lawrence Lupton with input from work colleagues.]

Correction

In the March 2015 edition of the Bulletin, one of the speakers at the CNA Winter conference was incorrectly identified. Mr. Hugh MacDiarmid is the Chairman of Terrestrial Energy Inc.

A Long Time Ago in a Company Far, Far Away

by JEREMY WHITLOCK

Attention Staff:

It has come to Management's attention that an inordinate number of non-standard "special days" are being openly observed by employees, based upon science and sci-fi trivia; for example: "Pi Day" (March 14). While Management supports the consumption of pie and does not wish to unduly restrict the ability of the bakery industry to derive financial benefit from its activities, we must all acknowledge that the image of our company as a haven for Big Bang Theory fan boys (and girls) deriving pleasure from esoteric humour unbefitting a commercial entity, is not, in of itself and notwithstanding personal, religious, and other rights and freedoms – desirable.

Accordingly, while we all certainly appreciated the assortment of pies distributed in the cafeteria on March 14 this year (marking an apparently particularly special occurrence of this day in 2015), henceforth employees are asked to exercise restraint in letting such observances go too far. In particular:

"e Day": February 7th (with special observance in 2018). Public demonstrations of exponential growth or decay in celebration of this most natural of all constants, can be educational and interesting; however, in the past there has been much confusion and inappropriate behaviour (in particular the demonstrations in our front foyer of population growth, ponzi schemes, viral transmission, and nuclear chain reactions).

"Avogadro Day": June 2nd. The mass release of dozens of moles in our main administration building on this day last year was a particularly challenging event to deal with, and employees are reminded that security is still seeking help in tracking down the perpetrators. By contrast, the previous year's activity of releasing dozens of colorful balloons filled to a volume of 22.4 litres each was more acceptable; however, the fistfight that broke out among the chemists (apparently over the question of what actual volume the balloons should be inflated to, given that day's temperature and pressure) was unfortunate.

"Barn Day": October 24th. Many of us were impressed by the teamwork and spirit shown by the team of nuclear engineers that raised a barn in 24 hours in the executive parking lot, using only hand tools and human energy. Had the visiting Board of Directors been able to remove their cars before they were enclosed by the structure that day, it is likely that this remarkable feat of engineering might have experienced more corporate uptake.

"Gravity Day": September 8th. Unfortunately, last year's 1 PM screening of the Sandra Bullock/George Clooney 2013 blockbuster in the cafeteria, complete with a serving of fig Newtons and plates of broccoli and cauliflower shaped like Albert Einstein, quickly degenerated to a free-for-all of food thrown at the screen by those unimpressed by the physics of low earth orbit as depicted by Hollywood.

"Star Wars Day": May 4th. While it is recognized that May the Fourth holds a special place in many employees' hearts, it has been decided that storm trooper and "Leia the slave" costumes are inappropriate in customer meetings, as are light sabre duels in the ventilation shaft, and wookie calls over the PA system. Employees are asked to try to quietly observe this day in the future – or rather, either do or do not: there is no "try".

"Enterprise Month": January 2017. We understand that a group known as the "NCC-1701 Committee" is planning a month of festivities, including "blueprint trivia" contests, requirements to say "whoosh" when walking through doors on site, and random drills involving klaxons going off and everyone gripping their desks and grimacing. It is felt that such activities over an entire month would be unduly distracting, particularly the expectation that employees overact for such an extended period of time.

In addition to these measures, be advised that "Father's Day" will no longer be referred to as "I'm Your Father's Day" in the company calendar, the company work-out room will no longer be known as the "He's Dead Gym", and the cafeteria's double-patty hamburger will no longer be labelled the Spielberger (available with ET Phone Home Fries and a large Clockwork Orange soft drink).

Thank you for your cooperation in this matter. As usual, concerns and suggestions should be directed to the company feedback mailbox, by clicking on "I've Got a Bad Feeling About This" on our intranet.

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