CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

SEPTEMBER 2014 SEPTEMBRE VOL. 35, NO.3

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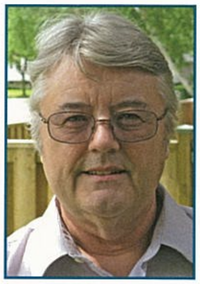
Safety Culture or the Blame Game – a 50 Billion Dollar Question



It has been four years since the blow-out at the Macondo well that caused an explosion on the deep-sea drilling rig, Deepwater Horizon, killing 11 workers and seriously injuring 17 others. The fire raged out of control despite firefighting efforts and was only extinguished when the vessel sank 36 hours later. Then some 5 million barrels of oil spewed into the Gulf of Mexico in an uncontrolled gush that lasted 87 days. Although several contractors were involved this well was under the primary control of BP, a U.K. based international oil company. Several other oil companies also drill in the Gulf area.

Immediately after the disaster the U.S. President ordered a moratorium on off-shore drilling only to have it lifted a few months later after legal lobbying from the oil and gas industry. However, it was the insurance companies that stopped the drilling, at least for a while - they refused to provide liability insurance until they reviewed the safety and emergency response plans of the drillers. At present the cap on liability is $75 million. It seems like a paltry amount, compared to what it has cost BP so far:

- The value of lost oil sums to $500 million assuming $100/barrel
- BP pleaded guilty to manslaughter and agreed to a criminal fine of over $4 billion
- BP has already spent some $28 billion on cleanup and claims settlements
- U.S. District Court Judge Carl J. Barbier ruled this month (September 2014) that BP was grossly negligent in the oil rig explosion that killed 11 workers, spilled millions of barrels of oil into the Gulf of Mexico and soiled hundreds of miles of beaches. He set new civil penalties against BP of $18 billion. (BP is expected to appeal this latest ruling.)

Despite a potential total financial loss of over $50 billion, BP has remained profitable, in part by selling some of its assets.

So how is this related to a good safety culture? Oil and gas lobbyists instead play the "Blame Game". BP has maintained that it was not totally responsible for the disaster. However, U.S. Court Judge Barbier found that BP was grossly negligent (not just negligent, which would carry much lower penalties under the Clean Water Act). Barbier ruled that BP acted recklessly and with "conscious disregard to known risks". He also pointed out that BP left out important details in its own internal investigation report, such as arguments over interpretation of test results that affected decisions on the day of the blow-out. Barbier leaned heavily on the independent and thorough investigation report to the U.S. President.

The President's investigating panel had several meetings with and presentations from the Institute of Nuclear Power Operators (INPO) who had made similar presentations to oil and gas company executives. U.S. Legislators had called for an "INPO-like" organization for self-policing the oil industry similar to the nuclear industry. INPO regularly visits nuclear power plants (including those in Canada) and issues a "Report Card" that is shared. It is a system of continuous leaning and improvement, a foundation of a good safety culture. It also keeps operators on their toes - they've each got each others' back, so to speak, and any sign of poor safety performance is not tolerated. In other words, all nuclear power plants are "Hostages of Each Other" (see book of same title by Joseph V. Rees).

The oil companies rejected an INPO-like structure. They claimed that self-policing would not work, intellectual property would be compromised, they could be seen as in collusion under competition rules, and many other "excuses".

Although there are numerous causal factors of the BP oil disaster, the root cause was the decisions made by BP in the 24 hours prior to the blowout - changing the abandonment plan at least five times with no assessment of the risks compared to the original plan that had been approved by the regulator.

Upon reading the BP report, the Commission's Chief Scientific and Engineering Advisor, Richard Sears, commented: "It appeared that for BP, the accident happened at 9:49 p.m. on April 20; whereas in some ways, the blowout began in early 2009 when they initially designed the well."

Is the "blame game" cheaper than a good safety culture? $50 billion says no.

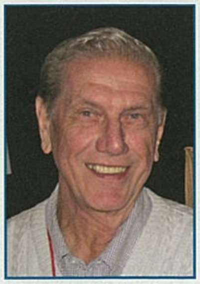
In This Issue

PBNC 2014 was a huge success and is the lead article in this issue. It was also the venue for this year's Honors and Awards ceremony, also reported in this issue.

We are pleased once again to have a history article from James Arsenault on Nuclear Energy and the Oil Sands, which readers may find a 1950s proposal very surprising! We also welcome our new CNS president, Jacques Plourde, in a review entitled "Meet the President". And as always, Jeremy Whitlock provides his take on nuclear in Endpoint.

I trust you all had a safe and enjoyable summer, and as always, your comments and letters are welcome!

From The Publisher



The Society and more

The past three months since the last issue of the *Bulletin* have been active ones for the Society, with the holding of the very successful *PBNC 2014 Conference* held in Vancouver the end of August and the first two (vigorous) meetings of Council for the 2014-2015 operating year.

PBNC 2014

A report on *PBNC 2014* is included in this issue. It is longer than the typical conference report because of the unusually large number of special and plenary speakers. Unfortunately, the number of special presentations precluded even listing the themes of the 300 excellent technical papers. However, as noted somewhere in this issue, a process for accessing the themes and titles of the technical papers has been developed. These were all of high quality and many from abroad. Go to website *www.pbnc2014.org* and follow the instructions. Full technical papers are available (for a modest fee) from the CNS office.

When one of our conferences attracts more than a third of its participants from overseas and receives praise from them it can be truly characterized as "successful". The fact that it also resulted in a significant positive financial outcome will, hopefully, assuage the financially focussed Council.

There is no doubt that the success of *PBNC 2014* is due to the initiative, determination and organizing ability of its proponent and basically overall chair, Frank Doyle, who proposed that CNS bid for this international event almost as soon as he became Past President in 2012. The basic Canadian team he corralled shared his enthusiasm and was eventually joined by over 70 team members many from other countries.

CNS Council

The primary focus of the 2014 – 2015 CNS Council to date has been dealing with the significant deficits accumulated in 2012 and 2013. This has led to the slashing of many programs, to the anguish of those around the Council table who had particular interest in one or more of those programs.

To the concern of those of us still involved in Branch activities this has included a proposed significant cut in the allotment to Branches.

As a complicating factor the future of this *Bulletin* became a significant sub-topic.

I had formally notified the Executive and Council last January that, after two decades, I felt I should withdraw from my various roles with the publication, which are broadly encompassed by the term "Publisher". I proposed leaving the end of 2014, after the December 2014 issue. For various reasons this was not on the Council agenda until the first meeting of the 2014-2015 year, in July.

At that meeting, with the deficit problem foremost, the focus was on going to digital format to reduce cost. However, at the early September meeting a number of Council members voiced their desire to maintain the printed version. With no unanimity, it was decided to take a poll of CNS members, to be conducted within the next few months. A sub-committee of Council has been established to design the poll but no specific date has been assigned for holding it.

Canadian nuclear program

There has been some positive news related to the Canadian nuclear power program.

A Chinese organization has indicated an interest in completing units 3 and 4 at the Cernavoda site in Romania. Candu Energy and its parent, SNC Lavalin, have signed agreements with other Chinese organizations for study and design of advanced CANDU plants. Planning continues for the refurbishment of the four units at OPG's Darlington site.

The CNSC approved the operation of Bruce B units 5 and 6 beyond the previously stipulated EFPH (equivalent full power hours) of 210,000 for their pressure tubes. And, L3 MAPPS, in Montreal, continues to sell its simulator expertise, most recently an upgrade for the one at Sizewell B in the UK.

However, the renewed session of the joint Environmental Hearing for OPG's proposed Deep Geologic Repository for low and intermediate radioactive waste at the Bruce site has resulted in just more outcry from various groups. That has included the Senate of the State of Michigan on the other side of Lake Huron.

As an observer it appears that OPG's response to a request from local administrations several years ago for a better way of handling this waste has been a disaster. The hearings have provided a platform for extreme accusations which have been spread by the general media. For four decades this waste has been handled safely and economically by special incinerators and containers. The proposed DGR was an unnecessarily extreme response.

Unfortunately, the platform afforded to extreme groups by these hearings has even led to discrediting CNSC, which has been the most effective voice for the safety of all parts of our nuclear program.

Fred Boyd

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~ Cover Photo ~

Personnel refine the prototype In-Core Flux Detector removal tool developed at Stern Laboratories.

Photo courtesy Wulf Bernhardt, Stern Laboratories..

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ISSN 0714-7074

The *Bulletin of the Canadian Nuclear Society* is published four times a year by:
The Canadian Nuclear Society
c/o AMEC NSS Limited
700 University Avenue, 4th Floor
Toronto, ON M5G 1X6
Telephone (416) 977-7620
e-mail: cns-snc@on.aibn.com

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

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

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

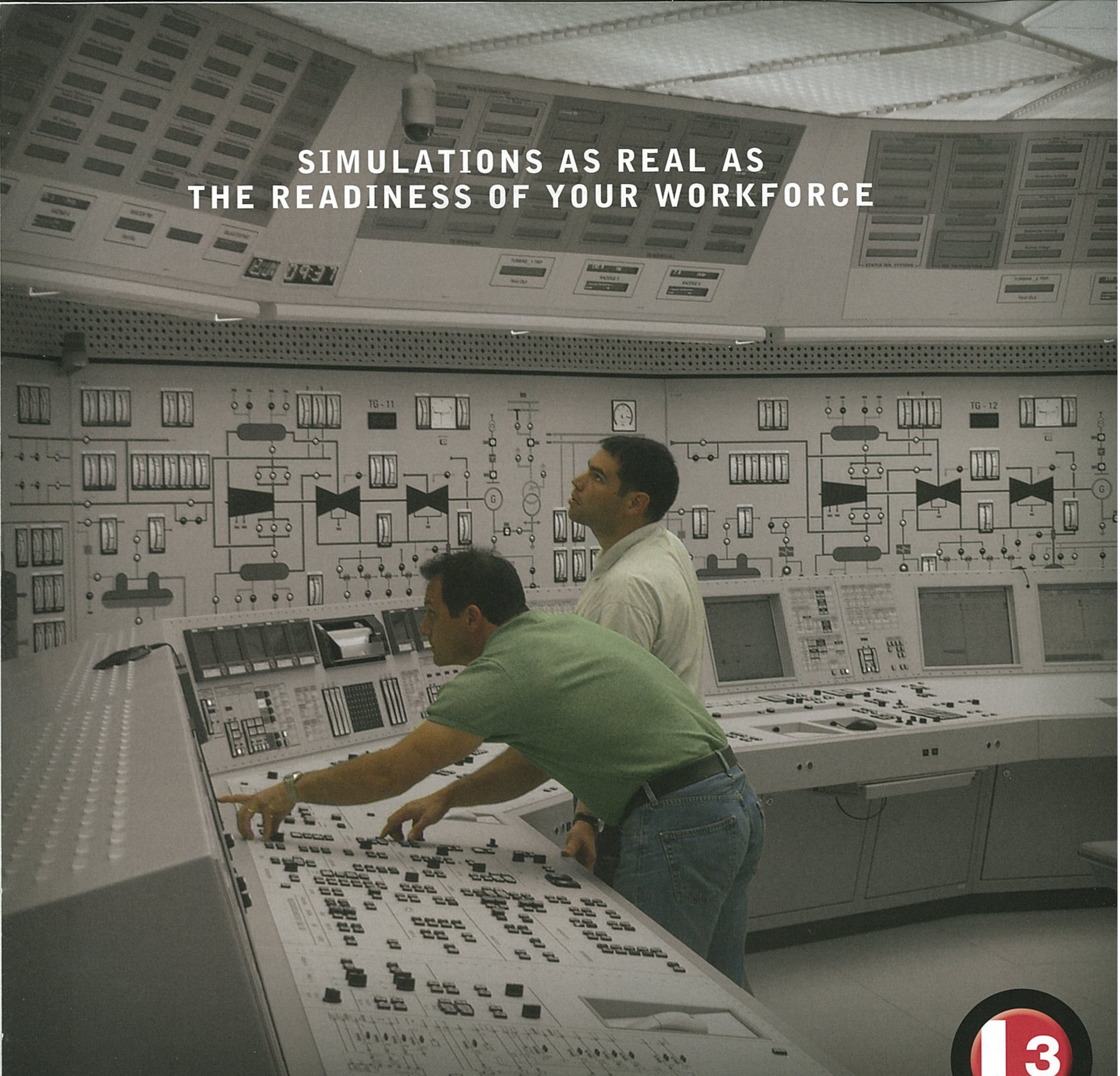
Editor / Rédacteur
Ric Fluke Tel. (416) 592-4110
e-mail: richard.fluke@amec.com

Publisher
Fred Boyd Tel./Fax (613) 823-2272
e-mail: fboyd@sympatico.ca

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

Printed by The Vincent Press Ltd., Peterborough, ON

Canada Post Publication Agreement #1722751


SIMULATIONS AS REAL AS
THE READINESS OF YOUR WORKFORCE

PBNC 2014 – An Unqualified Success

by FRED BOYD

The *19th Pacific Basin Nuclear Conference (PBNC)*, held in Vancouver, August 24 -28, 2014, was an outstanding success in all aspects. With the theme *Fulfilling the Promise of Nuclear Technology Around the Pacific Basin in the 21st Century*, it included 46 senior-level presentations, 300 technical papers from countries around the Pacific rim and others, 50 student posters and a number of exhibits from several countries.

The venue of Vancouver proved attractive to the large contingent of attendees from the Asian side of the Pacific Ocean, who constituted over a third of the 600 delegates.

Planning was extremely thorough and matched by the execution, with all events running on schedule. The hotel coped well with the larger than anticipated attendance despite packed dining rooms that challenged the waiting staff. A warm ambiance pervaded the event from the opening reception to the closing sessions (which were well attended).

Two optional technical tours were offered for the Friday – one to TRIUMF, the large accelerator on the campus of the University of British Columbia – the other to the laboratory of General Fusion Inc. in suburban Vancouver.

After the event, several overseas attendees sent brief congratulating messages, with words like, "superb"; "fabulous", "wonderful".

PBNC 2014 was the 19th in a series of biennial international conferences established by the Pacific Nuclear Council, a body composed of nuclear societies and associations of countries around the Pacific Rim. Member countries bid for the right to stage a conference. Canada held the 4th in 1983, and the 11th in Banff in 1998. PBNC 2014 was hosted by the Canadian Nuclear Society, the Canadian Nuclear Association and Natural Resources Canada.

The overall chairman of PBNC 2014 (officially Chair of the International Steering Committee) was **Frank Doyle**, a recent President of the CNS.

Other key members of the large organizing team (over 70 members from all of the countries involved) were: **Tim Gitzel**, Honorary Chair; **Ben Rouben**, Organization and Executive Administration; **Bill Kupferschmidt**, International Technical Program; **Ron Oberth** and **Daniel Brady**; Plenary and Keynote Speaker Program; **Doug Burton**, Sponsors and Exhibitors Program; **Emily Corcoran** and **Ruxandra Dranga**; Student Conference; **Krish Krishnan**, Honours and Awards; **Tracy Pearce**; Guest Program; **Jeremy Whitlock**, Communications; **Ken Smith**, Finance.

The Conference opened with a reception on the Sunday evening during which **Len Clewett**, Executive Vice-President and Chief Nuclear Officer, Bruce Power, gave a short opening address and welcomed the many delegates from abroad.

Promptly at 8:00 a.m. on the Monday morning, Frank Doyle began the program with general introductory remarks to a packed room (a feature that would continue for the full conference). He was followed by welcoming remarks from **Jacques Plourde**, CNS President; **Prof. Atsuyuki Suzuki**, president of the Pacific Nuclear Council; and **Dr. John Barrett**, president of the Canadian Nuclear Association.

Tim Gitzel, president of Cameco Corporation, and Honorary Chair of the conference, then introduced **Kelly Block**, Parliamentary Secretary to the Minister of Natural Resources, who spoke on behalf of the Minister, Greg Rickford. She emphasized the ongoing support by the Government of Canada of the Canadian nuclear industry.

For the four days of the conference the arrangement was a half day of plenary sessions and a half day of parallel technical ones, alternating mornings and afternoons.

The first Plenary Session, which followed immediately after the introductory remarks, was on the theme *Fulfilling the Promise – Developments Within the Pacific Rim.* As well as chairing the session, **Peter Lyons**, Assistant Secretary for Nuclear Energy at the US Department of Energy, delivered the first address, on *Past, Present and Future of Nuclear Power in the USA.* He noted the support of US president Obama for a Clean Energy Strategy. DoE is supporting the development of small modular reactors and studies of the possibility of extending the life of current nuclear plants beyond 60 years.

Atsuyuki Suzuki titled his presentation *Japan's Challenge – towards Creating a Most Robust Nuclear Energy Future.* He acknowledged that there had been a lack of safety culture in the Japanese nuclear program prior to the Fukushima event. Greater transparency is needed, he stated. In closing he referred to the problem of the inappropriate application of the LNT (Linear No Threshold) radiation concept which led to excessive evacuation.

The planning for the refurbishment of all four units of Ontario Power Generation's Darlington station was the focus of the presentation by **Pierre Tremblay**, president of Canadian Nuclear Partners, a subsidiary of OPG. It will be the largest such project in the world, he noted.

After a break, **Suo Wei**, of the State Nuclear Power Technology Corporation of China, used an interesting technique in his presentation by speaking Chinese but having slides in English accompanied by an English recording. He pointed out that China decided in 1970 to develop nuclear power. By 1984 it had designed its own version of a PWR plant. Now there are 20 operating units of different designs with 27 under construction. A standard design has been approved with mass construction to begin soon.

Another Asian success story was presented by **Kye-Hong Min**, Executive Vice-Chair of the Korea Atomic Industrial Forum. He began by noting that Korea must import 97 percent of its energy sources. Their nuclear program began in 1970 with a turn-key PWR plant followed a few years later with a CANDU unit (Wolsong 1). Over the following decades Korea has developed a completely indigenous nuclear program with the national utility, Korea Hydro and Nuclear Power (KHNP), as the central organization He noted the large project his country has undertaken in the United Arab Emirates.

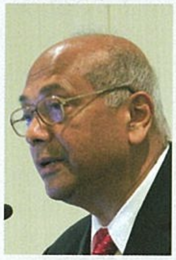
The final plenary presentation of the morning was given by **Javier Palacios** of the Instituto Nacional de Investigaciones Nucleares, Mexico. He noted that his country has one nuclear power station, at the two-unit Laguna Verde site. With the wish to decrease the use of fossil, studies are under way for two further nuclear units at the same site.

A short question and answer period was held before **Alexander Bychkov**, Deputy Director General, International Atomic Energy Agency, gave the second Keynote Address. He titled his presentation: *The Growth of Nuclear Power in the Pacific and IAEA's Support for its Development.*

He noted that of the 72 nuclear reactors under construction in the world, 48 are in Asia, primarily in China and India. In addition, several other Asian countries are planning nuclear programs. The IAEA offers support to these aspiring countries in a three-phrased approach: (1) energy planning and analysis; (2) a "Milestone Approach" for the preparation of the necessary infrastructure; and (3) training and assistance.

W. B. Lewis lecture

The W. B. Lewis series of lectures are sponsored by AECL in memory of Dr. W. B. Lewis, Senior Vice President of AECL from1947 to 1972 and a leader in the development of heavy water moderated, natural uranium reactors for power production. Normally included in the annual meetings of the Canadian Nuclear Society the organizers of PBNC 2014 decided to include it in this conference and scheduled it for immediately after lunch on the first day.



The invited speaker was **Dr. Srikumar Banerjee**, Homi Bhabha Chair Professor, Bhabha Atomic Research Centre (BARC), India. *(BARC is the original and premier nuclear research centre in India.)* Dr. Banerjee was Director of BARC from 2004 to 2010. In addition he served as Chairman, Atomic Energy Commission from 2009 to 2012. He titled his address *The Pressurized Heavy Water Reactor (PHWR) Technology – its Relevance Today.*

He began by noting India has a three stage program – PHWR; Fast Breeder Reactors; and Advanced HW Reactors. They are studying plutonium and thorium fuelling for their HWRs.

Turning to the evolution of the Indian program he noted the first PHWR unit in Rajastan in 1973 (which was essentially a copy of the 200 MWe Douglas Point plant in Canada and built primarily by Canadians). Subsequently India copied and improved the design and built a number of similar units. They then progressed to design 540 MWe and 700 MWe units following the same concept.

Given the country's thorium resources India is pursuing an Advanced HWR using U 233 and thorium. The current conceptual design uses vertical pressure tubes and light water cooling.

(Dr. Banerjee spoke just to slides. He offered to send a full text to AECL after returning home.)

Monday afternoon saw the first of the technical sessions. Subsequent technical sessions were held Tuesday morning, Wednesday afternoon and part of Thursday morning. There were as many as 10 concurrent sessions to accommodate the 300 papers accepted. *(All of the technical papers were recorded on a USB provided as part of the Conference package. Copies of the USB are available – contact the CNS office.)*

Lunch on Tuesday was followed by two events: (1) a presentation by **Tim Gitzel**, president and CEO, Cameco Corporation, and (2) the presentation of the **Canadian Nuclear Achievement Awards.**

Gitzel said the topic he was assigned was *Leadership in Challenging Times* and commented that when he "googled" the word "leadership" he got thousands of "hits". In his view, he said, we need leaders that can communicate with the public, media and government. Following the Fukushima event the nuclear community failed to communicate effectively, he stated.

He emphasized three points: (1) safety is the first priority (2) members of the nuclear community must be active within their general community, and (3) we must all speak out. "If we do not, who will ?", he challenged the audience in closing.

The Canadian Nuclear Achievement Awards presentations followed immediately after Gitzel's address. *(See the separate report on the Awards ceremony in this issue.)*

The Tuesday plenary session was divided into two parts, each with four speakers. The title for the first group was a long one, to accommodate the diversity of the presentations: *Fulfilling the Promise – Addressing the Challenges- Alternative Fuel Cycles and Fuel Supply.*

First was **Sermet Kuran,** Director of Advanced Fuel Candu Reactor and Fuel Cycles, at Candu Energy Inc.. The pressure tube core and on-power fuelling aspects of the CANDU design offers exceptional fuel flexibility, he stated. Candu Energy has partnered with the China National Nuclear Company (owner of two CANDUunits at Qinshan). One focus is on Natural Uranium Equivalent (NUE) fuel, a mixture of depleted uranium from discharged CANDU fuel and spent LWR fuel, which is still slightly enriched.

In addition, he said, the partners are starting the design of a "Generation III" Advanced Fuel CANDU design. This concept promises a synergistic relationship between LWR spent fuel and CANDU fuel.

Uranium supply and demand was the focus of the second speaker, **Derek Gross,** Director. Marketing Strategy, Cameco Corporation. While nuclear is predicted to continue providing just 12 per cent of global electricity, the latter is expected to grow significantly. Therefore there will be a growing demand for uranium, which he predicted would be about 4 per cent per year over the next decade.

He noted that for several years uranium demand has exceeded production. The difference has been met by "secondary" sources (primarily the dismantling of nuclear weapons). Those sources are essentially finished so the growing demand will have to be met by primary production (mining).

A view from the US Department of Energy, Office of Nuclear Energy, was provided by **Patricia Paviet,** Director of the Office of Systems Engineering and Integration. She reported that DOE-NE had funded a study of nuclear fuel cycle options. The study, titled *Nuclear Fuel Cycle Evaluation and Screening,* has identified attractive fuel cycles. But, she commented, any new fuel cycle would take years to be applied and would cost in the tens of billions of dollars to develop.

Noting that details of the study were far too extensive for a short presentation she suggested going to their website: *https//www.connect.sandia.gov/sites, nuclear fuel cycle options.*

The final speaker of this session was **Jarret Adams,** Vice-President Communications, AREVA Canada, who spoke on *Recycling and Advanced Fuel Cycles at AREVA.* He noted that AREVA's La Hague facility in Normandy, France, is the largest nuclear recycling plant in the world. The technology at La Hague, together with that of the MELOX plant in southern France provided the basis for the MOX Fuel Fabrication Facility being built at the Savannah River site in the USA.

After an extended break the second part of Tuesday's plenary began, also with a long title: *Fulfilling the Promise – Addressing the Challenges – Long-Term Used-Fuel Management.*

Ken Nash, President of the Nuclear Waste Management Organization (Canada), served as both Chair of the session and first speaker.

His opening address was titled *Addressing the Challenges: Long-term Used Fuel Management.* He noted that a primary focus of NWMO is to find a willing community with suitable technical attributes for a deep geologic repository. Four interested communities are still being evaluated. The concepts for the proposed DGR and for the proposed containers have been reviewed by, the Canadian Nuclear Safety Commission.

A trust fund, financed by the nuclear operating utilities will fully cover the cost and operation of the eventual repository, so there would be no financial burden for future generations, he noted in closing.

Next was **Shunsuke Kondo,** President of the Nuclear Waste Management Organization of Japan (NUMO).

The program for dealing with nuclear waste was established in Japan in 1973. In 2000 an Act was passed for *Specified Radioactive Waste Final Disposal.* That led to the creation of NUMO. In 2002 communities were invited to request information about the program. By 2007 only one community accepted the invitation then withdrew after local opposition developed.

The Japanese Science Council recommended seeking a consensus on the concept before proceeding further. In the meantime, spent fuel and general radioactive waste should be held in temporary storage.

A Basic Energy Plan, adopted by the government in early 2014, concluded: (1) nuclear power should continue: (2) geologic disposal should be pursued if necessary with site selection to proceed stepwise: (3) the nuclear community must communicate sincerely. NUMO has decided to produce a plan in 2015, he noted in closing.

A perspective from the USA was provided by **William Boyle,** director of the Office of Used Fuel Disposition Research and Development in the US Department of Energy Office of Nuclear Energy.

He referred to a major document issued by DoE in 2013 entitled: *The Strategy for the Management* *and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste.* It is a framework for moving toward a sustainable program to deploy an integrated system capable of transporting, storing, and disposing of used nuclear fuel and high-level radioactive waste from civilian nuclear power generation, defence, national security and other activities.

He noted that each utility must make its own decision on details of handling their spent fuel and high-level waste.

The final speaker in this session was **Liang Chen,** Deputy Director, Environmental Engineering Division BRIUG, China (BRIUG is the Beijing Research Institute of Uranium Geology).

A national fund for nuclear waste was established in 2010. Subsequently six regions were identified as possible locations for a deep geologic repository and three sites were considered suitable. Extensive studies have been conducted in Beishen in northwest China. An underground research laboratory is planned to be built in the area by 2020.

After a short break the afternoon sessions concluded with another keynote address, this time by Robert Norris, a member of the Saskatchewan Legislative Assembly and former Minister of several departments. He titled his address *High Potential: Saskatchewan's Uranium and Nuclear Future.*

With evident enthusiasm he spoke of the province's resources, its population growth and low unemployment. He spoke particularly about the role of Cameco in employing a large number of indigenous people in the northern part of the province. He closed by referring to the new Sylvia Fedoruk Centre for Nuclear Innovation.

Student Poster Session

Immediately after the talk by Norris the student poster session opened, combined with a wine and cheese reception. There were 53 posters on display. Their high quality created a challenge for the small army of reviewers. After more than two hours of review the score sheets were gathered and sorted. The winners were announced by Emily Corcoran following the Wednesday lunch. They were:

Undergraduate: **Jasper Martin,** University of Calgary, Certificate and $300

Title: *Small Modular Reactors – Electricity Generation in Canada's Yukon Territory*

Masters: **Dylan Pierce,** Royal Military College, Certificate and $400

Title: *Mitigation of End Flux Peaking in Candu Fuel Bundles Using Neutron Absorbers*

PhD: **Amjad Farah,** University of Ontario Institute of Technology, Certificate and $500

Title: *Life Cycle Assessment for GHG Emissions from an Eskom Pebble Bed type Modular Reactor*

AECL President Robert Walker presents a plaque to Dylan Pierce, Royal Military College, for best poster in the Masters category of the Student Poster competition.

AECL President Robert Walker presents a plaque to Amjad Farah, University of Ontario Institute for Technology, for best poster in the PhD category of the Student Poster competition.

Wednesday morning saw the third plenary session with another long title: *Fulfilling the Promise – Building for the Future – Developing New Reactor Technologies and Applications.*

John Kelly, Deputy Assistant Secretary for Nuclear Reactor Technologies, US DoE, served as chair and as the first speaker. He titled his presentation: *Advanced Reactor Program in the United States.*

To meet the President's Clean Energy goals will require a shift in electricity production, he noted. However, in recent projections for 2035, SMRs (small, modular reactors) have not been credited. He did note that three nuclear plants are under construction. However, he commented, their cost is high compared to natural gas. He commented, SMRs can be a "game changer" and DoE is supporting their development with $450 million over six years.

He also noted DoE's involvement with the Generation IV International Forum which is pursuing six basic designs. DoE is primarily focussing on fast reactors.

The Korean program was outlined by **Won Jae Lee,** Project Manager, Strategic R & D Program, at the Korea Atomic Energy Research Institute, in a presentation titled: *Status of Advanced Nuclear Reactor Development in Korea.*

He mentioned their studies of a sodium fast reactor; a very high temperature hydrogen cooled design, and a small reactor, called SMART, using proven technology to ease licensing.

Adrian Paterson, CEO of the Australian Nuclear Science and Technology Organization (ANSTO), spoke primarily about their studies of small modular reactors. He expressed the view that SMRs would be attractive to, and suitable for, countries wishing to begin a nuclear program.

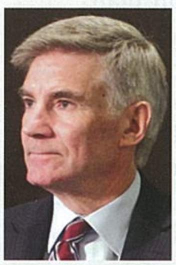
He also commented that SMRs could be especially suitable for small island nations.

A complete change of focus was offered by **Michael Delage**, Vice-President. Strategy and Corporate Development, General Fusion Inc.

There are two broad approaches to achieving nuclear fusion, he commented, magnetic and inertial. The large facility CERN in France is pursuing the magnetic approach. Although inertial fusion promises much higher energy intensity it is difficult to maintain. His company, General Fusion, is pursuing a magnetized target fusion process where the fusion target is surrounded by a lead blanket which absorbs and holds the heat from the very short reaction.

Development of a modular High Temperature Gas Reactor was the primary focus of the presentation by **Yuliang Sun**, Deputy Director, Institute of Nuclear and New Energy Technologies at Tsinghua University, Beijing, China. His Institute is also studying a Very High Temperature reactor design using helium as the coolant.

During the short Q and A period both Lee and Kelly commented that a different licensing approach is needed to deal effectively with SMRs.



The second part of the Wednesday plenary sessions was chaired by **Mark Elliott,** Senior Vice President and Chief Nuclear Engineer, Ontario Power Generation, who also gave the first presentation, on the topic *Safely Extending CANDU Life.*

He emphasized at the beginning that OPG's extensive refurbishment plans are being developed and will be executed in cooperation with many other organizations.

Then he turned to his own experience, commenting that he was at the start-up of the Pickering B station. He noted that that the Canadian Nuclear Safety Commission in June 2014 had removed a "hold point" that had been set at 210,000 Equivalent Full-Power Hours (EFPH) to permit operation up to 247,000 EFPH. He now looked at five years more production up to the decided retirement in 2020.

Regarding the planned Darlington refurbishment he reported that OPG had just received the highest rating by WANO (World Association of Nuclear Operators). A major inspection of all components is still underway, he noted, and complimented the CNSC for its involvement since the beginning of the refurbishment plan.

New build was the focus of the next speaker, **Ken Petrunik,** who, for five years, has been the Advisor to the CEO Nuclear Power, Emirates Nuclear Energy Corporation. In that role he has been overseeing the turnkey contract between the United Arab Emirates (UAE) and the Korea Electric Power Corporation for four Korean designed APR 1400 units at Barakah in the UAE. Earlier Petrunik had been involved in the construction of several CANDU units overseas, including the two units at Qinshan, China.

The UAE project is the result of a major contract with one company, he noted. There has been very thorough planning and extensive collaboration with the vendor, he said, and the project is on schedule. Since this is the first nuclear venture of the UAE it was decided to follow the licensing system of the country of origin, Korea.

Garry Young, Director, Licence Renewal, Entergy Nuclear, provided an overview of the move to longer-term operation of nuclear plants in the USA.

As of early 2014, the US Nuclear Regulatory Commission had approved extension of the licences for seven plants to 60 years, from the original 40 years. Over 90 plants have applied for a similar life extension. A typical renewal application takes four years, he said, two for preparation and two for NRC review.

There is now considerable discussion about extending licences to 80 years, he commented. On the other hand, four more plants have announced that they would shut down at the end of their 40 year licence.

The final presentation of the Wednesday plenary sessions was given by **Frank Yee,** Chief Nuclear Engineer, Candu Energy Inc. He spoke on *Infrastructure Needed for Success – An OEM/NSP Designer's Perspective.*

A company such as Candu Energy is part of a large team, he stated. There is a need for a healthy supply chain and proactive government support, he asserted. Additional requirements are: a capable work force; continued research and development; and profitable utilities. All of these groups need to work as a team, he contended. In that context he closed with a comment from hockey, "there is no such thing as an unassisted goal".

Following the lunch there was a further Keynote Address by **Robert Walker,** President and CEO, Atomic Energy of Canada Limited, who titled his presentation *Nuclear Science, Technology and Innovation in Canada – Securing the Future.*

AECL is Canada's primary research and technology organization, he stated, then asked the rhetorical question, "where is Canadian R & D going?". He noted the move to a GOCO (Government owned, Contractor-operated) system for the Chalk River Laboratories and stated that a decision on the operator would be made in 2015.

After reciting some of the roles of CRL such as dealing with historic waste and providing science advice to government he turned to what he said were personal comments. There are challenges to the entire science and technology community, he asserted, and mentioned, in particular, the public concern about radiation. We must communicate better to gain public trust, he said in closing.

That evening saw the conference banquet, followed by a music and dance presentation by a First Nations group.

The Thursday morning began with a shortened Plenary session. Although this was the final day and each presenter was limited to ten minutes the audience still filled the room.

Michael Binder, president of the Canadian Nuclear Safety Commission served as Chair and first speaker.

He opened with the statement, Fukushima was a "game changer". Then he listed four challenges: (1) dealing with "beyond design basis" events, i.e., how to deal with events of very low probability but very large consequences (2) extending the life of a nuclear plant beyond the original design life (3) peer review versus national sovereignty (4) public acceptance.

Then he introduced the first of his fellow panelists, Un Chul Lee, Chairman, Nuclear Safety and Security Commission, Korea.

Lee referred to Korea's recently adopted National Policy for Nuclear Safety, which includes: (1) public participation with improved transparency, (2) peer review, (3) life extension, and (4) dealing with severe accidents.

Juan Eibenschutz, Director General, Comisión Nacional de Seguridad Nuclear y Salvaguardias, Mexico, was the next panelist.

He said public perception was the main challenge that needs to be overcome if nuclear power is to play a more significant role. However, he noted, it is impossible to guarantee that there will never be a severe accident.

Another regulatory perspective was offered by **William Ostendorff,** a Commissioner on the US Nuclear Regulatory Commission, who began by joking about his own life extension, having just received a knee replacement. He listed the desired attributes of a regulatory organization as: technical competence; program for active stakeholder engagement; and open and transparent communication. USNRC tries to meet these requirements, he said.

Binder invited questions from the floor leading to a short but spirited discussion. He responded to one about passengers still using airplanes despite accidents by saying individuals have a choice whether they fly or not while a regulator makes the decision about the building and operation of a nuclear power plant.

The balance of the morning was devoted to the final technical sessions.

After lunch, **John Barrett,** President and CEO of the Canadian Nuclear Association provided a further Keynote address, on the topic *The Path to Fulfilling the Promise.* Countries with nuclear programs must work together, he stated. They all should be striving for excellence and, he offered, they all have a moral obligation to be open. To regain public trust strict regulatory standards must be applied, he asserted.

Following the last day lunch a final plenary session was held under the title *Fulfilling the Promise – Telling our Story – Communications and Outreach Discussion.* This was co-chaired by **Mimi Limbach,** Potomac Communications Group and **Kune Suh** from Seoul National University, Korea. Despite the timing the room was still full.

Limbach stated that, in her experience, the major challenge is making technical information understandable to the average citizen. Suh commented on the misinformation that followed the Fukushima event such.as early reports that three plants had melted.

Michaele Brady Raap, President, American Nuclear Society, spoke about her organization's evolving program for improving the conversation with the public. However, she commented, it is difficult to keep up with the exaggerated and false information spread by the "antis" and the mass media. ANS has decided to go beyond being reactive and become proactive in its communication plan.

Three basic themes have been chosen: (1) radioactivity is part of the world (2) nuclear technology works safely (3) nuclear technology enhances our quality of life. ANS has initiated training for spokespersons, is developing further social media, is communicating with policy makers and holding workshops for teachers.

Lixin Shen, Deputy Secretary General of the Chinese Nuclear Society, noted three attributes of nuclear power which make the message challenging – the technology is complex; sudden accidents do occur; and the science is difficult. He commented that the Chinese public is becoming more aware of environmental problems.

Another perspective from the USA was presented by **Scott Peterson,** Senior Vice-President – Communications, Nuclear Energy Institute. He said the Public Trust Index for nuclear had declined in the USA. He listed the following elements of strategic communications: outcome; environment; message; source or person delivering message; the tools used to communicate; how to respond to critics. Visual messages are important, he noted, so NEI is using more social media.

The final speaker in this session (and of the conference) was **Jeremy Whitlock,** Manager of Non-Proliferation and Safeguards, Atomic Energy of Canada Limited but more widely known as the host of his own website (The Canadian Nuclear FAQ) and his activities as Communication Director of the Canadian Nuclear Society.

He began with the statement – a great story, poorly told. It is not all bad, he asserted and referred to the establishment and work of the Nuclear Waste Management Organization and its extensive program of public engagement. He ended with three requirements: (1) the need for a pan-industry approach; (2) the need for a strategic, multi-year, communication plan, and (3) the need for all involved in the nuclear program to participate in telling the positive story.

That ended the formal conference but several procedural events followed.

First, as chair of the International Steering Committee for PBNC 2014 (and prime organizer) Frank Doyle handed a symbolic cheque to Mimi Limbach, new Chair of the Pacific Nuclear Council, for the right to hold this 19th PBNC.

Then he turned to Lixin Shen to extend an invitation to PBNC 2016. Shen presented a short slide show of Beijing, China, the venue for the 20th Pacific Basin Nuclear Conference, and the plans for the event.

Bill Kupferschmidt thanked all involved in the Technical Program. Frank Doyle thanked Bill, Paul Fehrenbach and Murray Stewart (who both had provided considerable input based on their experience with the 1998 PBNC held in Banff), Emily Corcoran for the student conference and Ben Rouben who had been responsible for all of the logistics.

With the comment that he believed they had achieved their dream of having a very special conference, Frank Doyle declared PBNC 2014 closed.

Postscript

The conference was made financially possible by the sponsorship of many organizers and the involvement of a number of exhibitors.

Sponsors

Co-hosts: Canadian Nuclear Society; Natural Resources Canada; Canadian Nuclear Association; in collaboration with the International Atomic Energy Agency.

AECL; Candu Energy; Cameco; Kinetrics; Power Workers Union; Westinghouse; Ontario Power Generation; Bruce Power; Canadian Nuclear Safety Commission; Comtech; Energy Solutions Canada; SNC Lavalin Nuclear; Fedoruk Centre; GE Hitachi; TUV.

Exhibitors: AECL; Ahlberg Cameras; AREVA;ATI; B&W; Cameco Fuel; Canberra; Candu Energy; CNSC; Consolidated Controls; Energy Solutions; Kanata Electronic Services; Energy Solutions; Hitachi; Kinectrics; Korea Atomic Industrial Forum; Doosan; KHNP; Kepco; SYT; L3 Mapps; Mirion Technologies; DSScience; Philosophia; NWMO; PLC; Clean Energy Solution; OCI; Power Workers Union; Rosatom; SNC Lavalin Nuclear; Fedoruk Centre; Westinghouse; Canadian Nuclear Revitalization Partners; Women in Nuclear.

Some of the key players in the conference pose for a group photo. L to R Jacques Plourde, CNS President; Bill Kupferschmidt, AECL VP and Conference Technical chair; Robert Walker, President AECL; Tim Gitzel, President Cameco and Honorary Conference Chair; Michael Binder, President CNSC; John Barrett, President CNA; Frank Doyle; Conference Chair.

Canadian Nuclear Achievement Awards

The 2014 Canadian Nuclear Achievement Awards ceremony was held at a luncheon ceremony on Tuesday, August 26, in the Hyatt Regency Hotel, Vancouver, B.C. during the 19th Pacific Basin Nuclear Conference.

The award ceremony has typically been held during the Annual General Meeting of the Canadian Nuclear Society. However, the CNS decided not to hold their AGM in 2014 in favour of co-sponsoring, with the Canadian Nuclear Association and Natural Resources Canada, the international 19th PBNC. *(A report on the PBNC is included in this issue of the CNS Bulletin.)*

Following is a report on the awards presented. Some awardees were unable to attend the ceremony in person.

Harold A. Smith Outstanding Contribution Award

Note: In 2014 this award was retitled by adding the name Harold A. Smith, who was a senior engineer at the Hydro Electric Commission of Ontario (HEPCO) the forerunner of Ontario Hydro, now Ontario Power Generation. In the early 1950s he led the small group at the Chalk River Nuclear Laboratories that developed the concept of a natural uranium fuelled, heavy water moderated reactor for power generation.

The purpose of this award is to recognize Canadian-based individuals, organizations or parts of organizations that have made significant contributions in any field related to the beneficial uses of nuclear energy. These contributions may be either technical or non-technical. There are two categories of the award, one for individuals and another for organizations or parts of organizations.

Award
Fred Boyd

Fred Boyd has had an illustrious career in the Canadian nuclear industry. After graduating from the University of Toronto, he joined AECL and then Canadian General Electric to work on the design of NPD, Canada's first nuclear electric power station. He was later appointed as Head of Nuclear Facility Licensing for the AECB (now CNSC). Working closely with the AECB President, George Laurence, Fred developed the Canadian Siting Guide for nuclear power stations. He then served as a nuclear energy advisor in the Department of Energy, Mines and Resources and later represented the IAEA as advisor to Korea on regulatory issues.

Fred has contributed significantly to the establishment of Canadian nuclear safety culture, and has numerous publications in the national and international literature. He developed the basic Canadian nuclear philosophy and licensing systems. He has contributed to the development of AECB policies.

Fred has been a member of CNS in various capacities since its early days. He was also an active member of three CNA standing committees. As Editor of the CNS Bulletin he transformed it into a high-quality quarterly publication. He is a Member Emeritus of ANS. He was appointed Fellow of the CNS in 1994 and Fellow of the Engineering Institute of Canada in 2004.

CNA President John Barrett(R) presents the Harold A. Smith Outstanding Contribution award to Fred Boyd.

John S. Hewitt Team Achievement Award

This award recognizes the recipients for outstanding team achievements in the introduction or implementation of new concepts, or the attainment of difficult goals in the nuclear field in Canada.

Award
CNSC Radicon Team

The RADICON study (Radiation and Incidence of Cancer around Ontario Nuclear Plants from 1990 to 2008) was conducted by a team of dedicated staff of the Canadian Nuclear Safety Commission (CNSC). The study found that there is no evidence of childhood leukemia clusters in the communities within 25 km of the Pickering, Darlington and Bruce NPPs and also that all cancers are well within the natural variation of the disease in Ontario.

The study used a novel approach of combining environmental monitoring, radiological release data and radioactive plume modelling with real cancer statistics. The results were published in the September *2013 Journal of Environmental Protection* and have received considerable national and international attention. The study was also intrumental at several important public hearings and meetings in 2013.

The study is an excellent example of research conducted at the CNSC by a multi-disciplinary team of scientists and a communications specialist. It has made significant contribution to the world of radiation protection.

Pictured left to right - Seated: Julie Burtt, Rachel Lane. Standing: Patsy Thompson, Elias Dagher, Laura Anderson.

CNS Past President Adriaan Buijs (L) presents the John S. Hewitt Team Achievement Award to Elias Dagher representing the CNSC Radicon Team.

George C. Laurence Award for Nuclear Safety

The *George C. Laurence Award for Nuclear Safety* was established in 2012 - named in honour of Dr. George C. Laurence, who was the first full-time President of the Atomic Energy Control Board (now the Canadian Nuclear Safety Commission) from 1961 to 1970. He was a strong advocate of safety throughout his career.

This award is presented to an individual or team to recognize major contributions to the philosophy, science, and application of safety principles for nuclear reactors.

Award
Liliana Comanescu

Liliana Comanescu is currently the Principal PSA (Probabilistic Safety Assessment) Analyst at Candu Energy Inc. She previously worked for the Romanian design institute, CITON, and S.N. NuclearElectrica, Romania. Liliana joined AECL in 2001 and moved to Candu Energy when that company was formed in 2011. Over the last 30 years she has made significant contributions to the design and development of safety-related features in existing CANDU plants and future designs and has played pivotal roles in the success of the PSA programs for CANDU 6 refurbishment projects as well as operating plants. Following the Fukushima Daiichi accident in March 2011, she played a key role in the successful reassessment of the nuclear safety and emergency preparedness arrangements for Cernavoda NPP. Under her leadership, the Point Lepreau Refurbishment PSA program, which was executed successfully, was the first in Canada to be compliant with the regulatory PSA standard S-294.

Liliana has trained many staff within her company, the Canadian industry as well as off-shore in PSA. In 2009 she received AECL's Distinguished Merit Award for exemplary contribution to the successful completion of the PSA project.

CNSC President Michael Binder presents the George C. Laurence for Nuclear Safety award to Lilianna Comanescu.

Education and Communication Award

The *Education/Communication Award* was established by the Canadian Nuclear Society in 1997.

This award recognizes the recipients for significant efforts in improving the understanding of nuclear science and technology among educators, students and the public. Two awards were made.

Awards
Paul Hinman (posthumously)

Paul Hinman is an excellent example of the power of grassroots outreach.

Paul graduated from the University of Alberta in 1972 and worked as a systems analyst for the Alberta government until his early retirement in the mid 90s, due to his struggle with Crohn's disease. His earlier interest in nuclear energy led him to participate in CNS education and outreach activities, while he continued to learn more about nuclear energy.

Paul first participated in the Mighty Peace Teacher's Convention in 2008, where he learned of the annual Alberta Teachers Association Science Conferences and recommended them as a good venue to inform science teachers and their students about nuclear science and opportunities. This led to distribution and demonstration of Geiger counter kits to about 33 high schools in Alberta. Paul also participated in a number of nuclear discussion forums in Alberta.

The Canadian nuclear industry is fortunate to have had Paul's involvement during its foray into public education and outreach in Alberta. He was an intelligent, thinking, compassionate layman, who learned enough about nuclear energy to appreciate its risks and the benefits to humanity. He made nuclear outreach his hobby for the remaining years of his life, participating in and leading many CNS sponsored activities. He even booked speaking engagements at long-term-care facilities between bed-ridden hospital stays. Paul died from the effects of his long-term illness on May 13, 2013.

CNA president John Barrett presents the Education and Communications Award to the son of Paul Hinman who died in 2013.

Steve Aplin

Steve Aplin is the creator and author of the web site *Canadian Energy Issues - Where energy converges with environment in Canada and the rest of the world.* His web site provides the reader with immediate access to his latest blogs and also to automatic tables linked to the *Ontario's Independent Electricity System Operator* (IESO) output of electricity generation data. The tables provide the user with the carbon intensity of the Ontario grid as well as each electricity source. Presented in a simple but factual manner, these tables illustrate the importance of nuclear generation to the Ontario grid, and the carbon emissions of the generation sources.

Steve has written a variety of factual articles on the state of energy supply and use in Ontario, Canada and the world. These include assessments of Ontario politics, the German nuclear phase out, the ban on incandescent light bulbs, wind energy, emissions trading, ethanol, AECL, nuclear medicine, to name but a few. He is a prolific and thoughtful writer, invites others to respond, and responds to comments.

Steve has expended a great deal of effort into assessing energy and electricity in Canada, especially Ontario. Not only is he responsible for a thoughtful and thought-provoking web site, but he features in the media, such as on TV Ontario's *The Agenda,* or writing in the *Financial Post.*

CNA President John Barrett (R) presents the Education and Communication Award to Ron Oberth who accepted it on behalf of the winner Steve Aplin.

Fellow of the Canadian Nuclear Society

CNS members who are appointed Fellows of the Canadian Nuclear Society belong to a membership category established by the Society in 1993 to denote extensive contributions to the Society and meritorious service to the nuclear field in Canada.

Dr. W.C.H. Kupferschmidt

Dr. W.C.H. (Bill) Kupferschmidt is the Vice-President of Research and Development at Atomic Energy of Canada Limited (AECL), based at Chalk River Laboratories. Bill is a Fellow of the Chemical Institute of Canada, a member of the Canadian Nuclear Society. Bill received the Canadian Nuclear Outstanding Contribution award in 2012.

Over his almost 30-year career, Bill has made outstanding contributions to the furthering of Canadian nuclear technology. Throughout, he has always worked collaboratively with universities, industry and other organizations to ensure the impact of those results would be the best for the nuclear industry.

He has provided generous support to the Canadian Nuclear Society, encouraging AECL staff to participate in numerous CNS events and activities, and to serve in a variety of executive and nuclear education roles. Bill has also represented AECL and Canada internationally. He has always been a strong supporter of AECL's membership and participation on the OECD's Nuclear Energy Agency committees, such as the Committee for the Safety of Nuclear Installations. He currently chairs an IAEA Technical Working Group for Heavy Water Reactors. He is the Chair of the International Technical Program Committee for PBNC 2014.

CNS Past President Adriaan Buijs (L) presents the certificate to Bill Kupferschmidt naming him a Fellow of the Canadian Nuclear Society.

R.E. Jervis Award

The R.E. Jervis Award recognizes excellence in research and development as well as in overall academic achievement by full-time graduate students in nuclear science and technology.

The award was established in 1992 by former students of Professor Robert E. Jervis of the University of Toronto and the CNS to honour his achievements. The award was in the past administered by the University of Toronto, and is now sponsored and administered by the Canadian Nuclear Society.

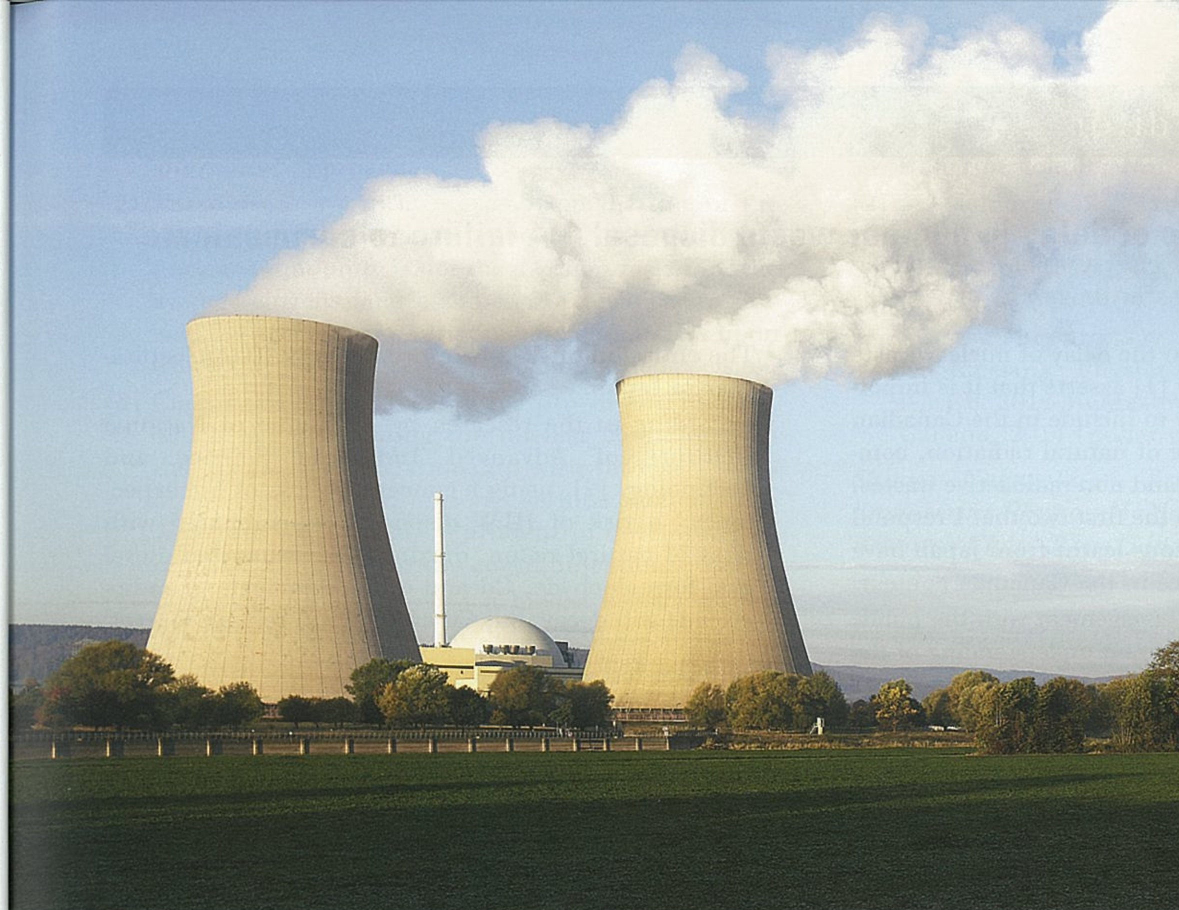
Madison T. Andrews

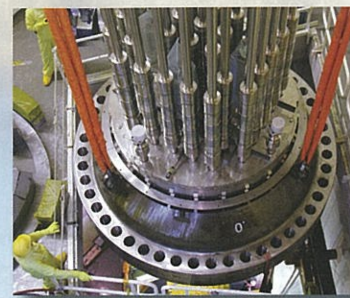
Madison Andrews is a PhD student in the Department of Chemistry and Chemical Engineering at the Royal Military College of Canada (RMCC). Her work has led to the development of a Delayed Neutron Counting (DNC) system for the analysis of special nuclear materials (233U/235U and 239Pu/235U) using the SLOWPOKE-2 facilities at RMCC. The DNC system is part of RMCC's contribution to the national capability in nuclear forensics in collaboration with Health Canada, AECL, RCMP, Defence Research Development Canada, and the National Research Council of Canada. The DNC system is important to national security as it is a method for non-destructive characterization of the isotopic abundance of special nuclear materials.

Madison's work has attracted international interest. She completed three internships at Los Alamos National Laboratory (LANL), where she modelled the DNC system and experimental data. Her work has been included as a new delayed-particle test set in the 2013 MCNP6 update release.

Madison is the recipient of an NSERC PhD scholarship sponsored by the Canadian Nuclear Safety Commission in 2013. She has completed three first-author peer-reviewed journal papers, ten conference papers, three technical reports, and two theses.

CNS Past President Adriaan Buijs (L) presents the R. E. Jervis Award to Madison Andrews.





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Response to "Decades of delay in nuclear waste disposal – A failure to communicate"

by SHINYA NAGASAKI, McMaster University

In a recent opinion piece on the delay of nuclear waste disposal, Mr. H. Tammemagi [1] asserts that it is important for a nuclear community to include in the Canadian public discourse the presence of natural radiation, comparisons between radioactive and non-radioactive wastes, and nuclear medicine. It is to the first two that I respond to, with the view that the lessons learnt from Japan have merit for addressing the issues in the Canadian context.

In Japan, 20 years of active engagement with the public sought to promote a better common understanding of the high-level radioactive waste (HLW) management, before the accident at Fukushima . This endeavour involved: Japans' Ministry of Economy, Trade and Industry (METI); Nuclear Waste Management Organization of Japan (NUMO); the Federation of Electric Power Companies of Japan (FEPC); and experts from the nuclear industry, universities, and research institutes in Japan (including the author). The nuclear community in Japan had developed and shared narratives on key topics, including the following:

(i) Natural Radiation

- Radiation is found throughout nature, coming from space, soils/rocks, air, and foods. Japanese annual dose rate from foods is approximately 0.3 mSv/year.
- In Japan, the maximum annual dose rate by natural radiation (except the contribution from air) is approximately 1.19 mSv/year (in Gifu Prefecture), and the minimum is approximately 0.81 mSv/year (in Kanagawa Prefecture). The difference is 0.3-0.4 mSv/year; no statistically significant difference has been observed in the rate of oncogenesis or teratogenicity between the two prefectures. Moreover, in areas of the world where the natural radiation background level is extremely high (e.g. Guarapari, Brazil), an increase in the rate of oncogenesis or teratogenicity has not been found.
- In comparison, regulatory cut-off standard for low-level radioactive waste (LLW) disposal is 0.01 mSv/year (the criteria for HLW disposal is undecided), and the maximum annual dose rate from its disposal is much less than 0.01 mSv/year. The maximum annual dose rate in the safety assessment of HLW disposal is predicted to be even less than 0.01 mSv/year.

(ii) Non-radioactive wastes

- If 50% of the electricity consumed by a Japanese person for 80 years is produced by nuclear energy, the volume of HLW is approximately that of three golf balls. This small volume is compared to the amounts of general and industrial wastes in Japan.
- The emission of CO_2 is approximately 10 ton/capita-year in Japan.
- According to the research by Dr. Gamo of National Institute of Advanced Industrial Science and Technology [2], using a concept of 'loss of life expectancy,' a risk of HLW disposal was compared with risks of natural radon, dioxin, PCB, exhausted diesel gas, formaldehyde, Cd and other chemicals. A radionuclide will decay, but Cd and Hg will remain forever.

(iii) Medicine and other uses

- Japan is one of the countries in the world in which the radiation exposure by medical treatment is very large. The radiation is also used in inhibition of germination of potatoes, creation of advanced materials, and non-destructive investigation. The radioactive wastes are generated from these activities, and the disposal of these wastes is also inevitable.

Many Japanese people could understand what the radiation and radionuclides are, what the impact of radiation exposure on human health is and how the radioactive wastes will be managed, through the consequences of Fukushima Accident, but not by the communication with the nuclear community. The nuclear community in Japan found that the public recognised that natural radiation is different from artificial radiation, and the former provides benefits and the latter creates risk to society. The public could accept the general and industrial wastes as unavoidable ones for their common lifestyles, but could not readily compare them with HLW. The public was not familiar with wastes from electricity generation. Much of the communication meetings with public stakeholders revolved around answering questions not only about HLW disposal, but also about nuclear energy, nuclear facility safety, and Japan's need for nuclear energy. It was difficult to steer the discussion towards HLW disposal. The site selection process of a repository for radioactive wastes generated by medical treatment has not progressed.

What the nuclear community in Japan learnt from the communication failure was less about the content than about the approach:

(1) The assumption that the main problem to public relations is the public's lack of knowledge (be it on natural radiation, non-radioactive wastes, and medical use of radiation and radionuclides), and that the role of nuclear community is to promote their understanding by education, typically represents an approach classified as the deficit model. A fruitful dialogue with the public cannot be estab-

lished at all, when the communication strategy is designed based on the deficit model – We need an alternative approach.

(2) There needs a critical reflection on the role of the nuclear community in relation to the public. The nuclear community is not the decision maker for the average citizens, and assumes responsibility to provide the necessary information and alternatives upon which the public can derive a well-informed decision.

(3) Classifying the public as either pro- or anti-nuclear, and hence positioning the nuclear community in the 'us vs. them' relationship with (at least) parts of the public sector, presents serious challenges to dialogue. We need to be prudent in developing an internal narrative for the communication.

(4) When the public perceives a hidden agenda or predetermined conclusions on the part of the organisers and facilitators of dialogues on nuclear issues, the basic mutual trust for meaningful engagement is compromised. The choice of organisers can reflect trustworthiness of such meetings with the public: In Japan, some meetings were planned, designed or hosted by METI, NUMO, or FEPC, by an organization like NPO which was entrusted by METI etc., or by an organization whose budget was partially supported by METI etc.

When the author asked engineering students at McMaster University and the University of Tokyo about their opinions on the communication about nuclear energy, it was interesting for the author to find that they believed that all stakeholders would naturally gather to a communication meeting [3]. But, in reality, it is a very tough task to identify the key stakeholders and secure participation from as many as possible. The information content is indeed important for planning and designing such a meeting; but it is critical, if not essential, to make clear the expected types of communication tasks, to make explicit the identity and role of facilitators or representative of nuclear community, and articulate the objectives and motivation for engagement by both the host and the participant groups.

The author thinks the communication between NWMO and the Canadian public is appropriate in sense mentioned in (1) to (4). The experts in Japan and US, with whom the author has acquaintance, also agreed with this opinion. In Canada, the site selection process has steadily been progressing. In Japan, they have a challenge not only of conventional HLW but also of new radioactive wastes generated by Fukushima Accident such as debris and decontamination wastes. The author agrees that Mr. Tammemagi's opinion is very insightful and that a variety of perspectives should be included in CNS Bulletin to help further our discussions. In order that the nuclear waste and HLW management are reasonably implemented in Canada, Japan, and other countries, the author is pleased that CNS members take initiative to further our understanding of the issues.

Finally, the author thanks Dr. Minha R. Ha of McMaster University for the fruitful and valuable discussion.

[1] H. Tammemagi, "Decades of delay in nuclear waste disposal – A failure to communicate", CNS Bulletin, Vol. 35, No. 2, 13-14, 2014.

[2] M. Gamo et al. "Ranking the risks of 12 major environmental pollutants that occur in Japan", Chemosphere Vol. 53, No. 4, 277-284, 2003.

[3] M. Ha and S. Nagasaki. "Development of Ethics Assessment Strategy for Senior Undergraduate Engineering Physics Course", Proceedings of iCEER 2014-McMaster, August 24-26, Hamilton, Canada, 2014 (under publication).

Shinya Nagasaki is Professor of Department of Engineering Physics, McMaster University, and Canada Research Chair (Tier 1) in nuclear fuel cycle and radioactive waste management.

[Ed. note: This letter has been edited for length.]

Response to the Letter to the Editor

By HANS TAMMEGAMI

I'm pleased my letter about nuclear communication has generated interest, and that Mr. Shinya Nagasaki has written such a lengthy and erudite response. Not familiar with the Japanese nuclear landscape, I cannot comment on his letter in detail. I can state, however, that the topics he mentions as having been presented to the public in Japan, have also been presented to the public in Canada by the various nuclear organizations. Yet we see no progress in implementing waste disposal, and the construction of new nuclear plants in Canada is stalled.

Informing the public about nuclear issues is a difficult and complex undertaking. As a writer, I have learned it is essential to speak simply and with an interesting narrative. Mr. Nagasaki's letter, although intelligently written, is an example of nuclear techno-speak, rather than people-speak.

Effective communication also requires that nuclear topics be placed in perspective, and not be considered in isolation. Thus, when discussing high-level nuclear waste, it should be constantly compared to other hazardous wastes with which people are familiar and their disposal sites, such as at Swan Hills, Alberta. In fact, an excellent strategy would have been to choose such a near-surface facility as one of the options for nuclear waste disposal. The environmental assessments would have compared the methods and clearly demonstrated the deep-disposal proposed for nuclear wastes is far superior, and at the cutting edge of waste disposal technologies.

The fear of nuclear has become deeply ingrained with much of the public, and it may not be possible to overcome the entrenched distrust. If progress is to be made, however, nuclear communicators (and decision makers) need to think outside the box.

Canadian Nuclear Power Principles for Beyond Design Basis Events – Supporting Rationale

by MARK ELLIOTT[1], GARY NEWMAN[2] and ALNOOR BHALOO[3]

[Ed. Note: The following paper was presented at the 19th Pacific Basin Nuclear Conference (PBNC 2014), Hyatt Regency Hotel, Vancouver, British Columbia, Canada, August 24-28, 2014.]

Abstract

The development of the following principles and their rationale began during a special Chief Nuclear Engineers forum held on March 25th, 2013 in Toronto. These principles are intended to provide guidance to the Canadian Nuclear Power Industry in developing responses to the lessons learned from the Fukushima event of March 2011. These principles were accepted and signed off by the Chief Nuclear Officers of each of the three utilities in August 2013 and were presented to the CNSC at a public hearing on August 21, 2013. This document provides the underlying rationale for the principles.

Overall Objective

The overall objectives of the measures adopted by the Canadian utilities in response to lessons learned from the Fukushima Event is to practically eliminate potential for societal disruptions due to a nuclear incident by maintaining multiple and flexible barriers to severe event progression.

Rationale:

The Canadian nuclear utilities have a responsibility to protect the population from adverse consequences resulting from a severe nuclear accident. If such an event were to occur, it could have serious societal impacts affecting public health, well being, the environment, the economy and the global nuclear industry.

The most serious and immediate impact to the population from a severe accident would be the release of a significant quantity of long-lived radionuclide such that public health and the environment are adversely affected in the long term. This impact would occur as a result of long- lived radionuclides leaving the site boundary and entering the population's living and working environment.

In the event of a nuclear incident where a significant quantity of long lived radionuclide is not released to the environment, the impacts on the population are from the loss of electricity (e.g., economic, quality of life) and possible health effects due to release of short-lived radionuclide; these impacts are serious but they are generally shorter in duration and, in most cases, are not life threatening. Also, temporary remedial and compensatory actions can be taken in such cases. In particular, sheltering, evacuation, short-term relocation and the use of potassium iodide are available defences that can be utilized as conservative responses against the release of radioactive noble gases and short lived radioiodines. However, the release of long-lived radionuclides such as Cs-137 can result in unacceptable, long-term contamination of the environment surrounding the plant. Therefore, the prevention of long-lived radionuclide releases is the single most important objective for protecting the public and the environment. The industry efforts need to focus on maintaining the barriers to such radioactive releases.

The industry will therefore focus on defences that prevent the progression of an event into a severe accident and, if a severe accident is not prevented, measures to mitigate accident progression such that a scenario that could lead to the release of a significant quantity of long-lived radionuclides is prevented.

Within the Design Basis there are multiple defenses engineered into the station that can provide additional water and electrical power to ensure adequate fuel cooling even for worst-case design basis events. These systems are designed to operate in the extremes of the Design Basis Accidents (e.g., loss of coolant accident, main steam line break, etc.). Events that are Beyond the Design Basis could be initiated by a severe external event (e.g., a seismic event or severe weather event that exceeds the design basis levels for the plant). Contingencies are required to adequately cope with events that are rare and credible.

Based on lessons learned from the Fukushima event, common mode external event initiators such as flooding, earthquakes, fire and high wind can affect multiple barriers leading to a complete and sustained loss of site electrical power. For these events, additional barriers and defenses must be put into place to protect against such extreme unforseen events and failures. These additional defences should be independent, diverse, simple, readily available and timely.

1 Chief Nuclear Engineer, OPG Nuclear

2 Chief Nuclear Engineer, Bruce Power

3 Chief Nuclear Engineer, New Brunswick Power

This principle has been endorsed in the conclusions of the August 2012 extraordinary meeting of the Contracting Parties to the Convention on Nuclear Safety: "*nuclear power plants should be designed, constructed and operated with the objectives of preventing accidents and, should an accident occur, mitigating its effects and avoiding off-site contamination.*"

1. Principle 1: Actions and defenses will focus on stopping accident progression prior to a severe accident

Rationale:

The most effective defence against the consequences of a severe event is to prevent the event from occurring in the first place.

CANDU nuclear power plants are designed to have multiple design-basis features to ensure that fuel cooling is maintained during a design basis event. During such an event, Emergency Operating Procedures are invoked to ensure that designed protective features are correctly deployed so that the key safety functions (control, cool, contain and monitor) are maintained. Based on lessons learned from the Fukushima event, certain common mode external event initiators such as flooding, earthquakes, fires and high winds can occur which can exceed the design basis for the plant. A beyond design basis event (BDBE) can affect multiple barriers leading to a complete and sustained loss of site electrical power. For these events, additional barriers are required to ensure that the event does not degrade into a situation that results in severe damage to the reactor core (i.e., a severe accident). Generally, the longer a severe accident is allowed to progress without fuel cooling, the more severe the consequences of the event. The earlier in the event progression that the event is brought to a steady state, the more effective is the mitigating feature in preventing societal disruption. Stopping an event from progressing to a severe accident provides assurance against any significant release of fission products.

2. Principle 2: Multiple barriers to event progression and multiple means to supply water or electricity will be used to ensure adequate defense

Rationale:

Multiple barriers to ensure fuel cooling provides redundancy and also allows the event to be terminated at various stages should one barrier fail or become unavailable. These barriers to fuel cooling are provided using Emergency Mitigating Equipment (EME) consisting of portable water pumps and portable AC generators.

During a loss of heat sink event, the continued absence of fuel cooling will result in accident progression through various phases. These phases include fuel melting, core disassembly and the formation of molten corium in the reactor vessel. In the extreme, the accident can progress to penetration of the calandria and shield tank by the molten corium, relocation of the fuel onto the concrete floor below the reactor and interaction between the molten fuel and the concrete floor; this phase is known as Corium Concrete Interaction (CCI). CCI is an extreme event that can result in severe challenges to the containment boundary and the large release of fission products to the environment. If a severe accident cannot be prevented, then the primary focus becomes the provision of cooling water to the reactor vessel (calandria vessel and/or shield tank) such that the event is stabilized before core debris, including molten corium, does not penetrate the reactor vessel. This configuration is known as In-Vessel Retention (IVR).

The industry has agreed that each utility should have multiple barriers to prevent or mitigate a severe accident, ensure IVR and prevent CCI from occurring in a Beyond Design Basis Accident (BDBA). These barriers would provide layers of defense for ensuring cooling of the fuel to minimize or eliminate radioactive fission product release, zirconium oxidation and CCI.

3. Principle 3: Methods and actions to initiate heat transport system cooldown and maintain fuel cooling will be a primary and early priority

Rationale:

In the event of a total loss of heat sink event, if the design basis methods of providing fuel cooling cannot be restored, the most effective alternate method of preventing a loss of heat sink event from progressing into a severe accident is to provide emergency cooling water to the steam generators. This is achieved by rapid cooldown of the steam generators through the boiler steam reject valves and by adding emergency makeup water to the steam generators.

Rapid cooldown of the steam generators serves two purposes. First, it provides rapid cooling and depressurization of the Heat Transport System (HTS). This increases the margin to fuel failures, reduces the energy introduced into containment via the heat transport relief system, and allows for EME to inject additional water into heat transport system when needed. Secondly, the release of steam from the steam generators by the open steam reject valves depressurizes the steam generators and allows for the injection of water from EME to the steam generators so that they can act as a sustainable primary heat sink. Since the steam generators are the primary and most important barrier for prevention of the progression of a beyond design basis event into a severe accident, robust means must be available to provide rapid cooldown of the steam generators, to enable the steam generator steam reject valves to be held open and to provide emergency cooling water into the steam generators.

4. Principle 4: Actions to maintain containment integrity will be utilized to minimize radioactive release

Rationale:

A breach of the containment boundary can result in the uncontrolled release of radionuclides in the event of a severe accident. Therefore, the key objective requires that containment integrity be maintained such that the release of long-lived radioisotopes that could result in long-term land contamination and permanent relocation is prevented.

Challenges to containment can occur due to a variety of factors. These include:

- Overpressurization of the containment envelope
- Hydrogen explosion
- Containment flooding

Therefore the control of containment integrity must be geared towards prevention of overpressure failure of containment, limiting the quantity of hydrogen in the containment atmosphere and controlling containment water level. These methods may include combinations of the following features: the existing Filtered Air Discharge System (FADS), Containment Air Conditioning Units (ACUs), water recovery systems (e.g. ECI Recovery, EWS Recovery, etc.), Containment Filtered Venting System (CFVS), Passive Autocatalytic Recombiners (PARs) and hydrogen igniters.

Regardless of the methods used to protect containment integrity, there needs to be some capacity for containment venting to enable venting of non-condensable gases.

5. Principle 5: Containment venting will be controlled through a filtered system.

Rationale:

Containment integrity is the final barrier to radioactive releases. With a functional containment, decisions can be made when to vent and for how long. This control is degraded when containment failures occur. Using this control, radioactive releases can be minimized. The ability to delay when containment will be vented allows for short lived material to be reduced through decay. At Fukushima delays in venting containment may have caused the failure of water injection into containment or systems due to containment pressures exceeding EME discharge pressure limits. Protecting containment integrity in order to prevent a breach of containment is critical.

When venting is required and transportable radioactive material is in containment then an ability to filter the discharge is needed. Options and methods should be utilized and made available where able to vent containment. Strategies to use FADs without power and with power in the event should be considered. Design options for Containment Filtered Venting System include a passive initiation by utilizing rupture discs or manual initiation by utilizing manual valves controlled by Operators. The philosophy to minimize decision making versus maintaining the operator in control can be mixed to varying degrees to give more timely decision making.

6. Principle 6: Necessary systems, structures and components (SSC) will be confirmed to survive rare yet credible conditions for external hazards

Rationale:

The systems, structures and components (SSC) which are required to function for rare yet credible beyond design basis events must be demonstrated to be capable of operating under the low probability, high consequence conditions for which they are expected to operate. This assurance can be provided by demonstrating that the credited SSCs are capable of surviving relevant external hazards at their credible Review level Conditions. An alternative approach is to demonstrate through fragility analysis that the SSCs have substantial margin beyond the design basis condition without specifying a Review Level Condition in advance.

A method to provide protection against hazards such as seismically induced internal fire or flood could utilize diversity and independence which could involve the use of a second connection points for water or power at a different location in order to mitigate the consequence of a lost connection point due to a fire or flood. The consideration of these approaches should be included in analysis, strategies and modifications to ensure our EME will add value at the time of the event.

Review Level Condition - is an appropriate estimate of the intensity of a rare yet credible external hazard (e.g. flooding) and used for a standard of capability for systems, structures and components to ensure adequate safety margin for beyond design basis events.

7. Principle 7: Irradiated Fuel Bay (IFB) water levels should be maintained sufficiently above the top of the fuel to mitigate high radiation fields, hydrogen production and fuel damage

Rationale:

Providing an emergency water supply to the IFB in the event of a total loss of AC power is critical to ensuring cooling of the fuel in the IFB. Maintaining an adequate level of water in the IFB will ensure low dose rates in the IFB area through shielding, will prevent hydrogen production due to fuel oxidation and will prevent fuel failures due inadequate heat removal.

Because of the importance of maintaining the fuel covered, it must be possible to provide emergency water to the IFBs using the EME pumps, and corresponding procedures and/or guidelines must be in place to ensure water make-up to the IFB. The target is to maintain water level in the normal range with EME equipment. Hazards are still possible from steaming and water overflowing out of the bay; however the primary hazard of fuel failures, high dose rates and hydrogen production will be precluded. The time required to respond to a loss of IFB cooling is typically quite long; therefore, it is regarded as acceptable to have a single method of providing emergency water to the IFBs. It is necessary to ensure that the capacity of the makeup water through EME exceeds the required capacity to make-up for evaporation and conservatively estimated IFB leakage, due, for example, to cracking of the concrete due to elevated temperatures.

The volume of water in the IFB during normal operation should be maximized within normal water levels to the extent practicable. This increases the time for heat up of the overall bay water and therefore increases response time for adding make-up water in a loss of IFB cooling event. Maximizing water within the bay volume is done by controlling and removal of objects that displace water such as spent fuel and other material such as racking, baskets and flasks.

Typically spent fuel is removed from the IFB to dry storage containers after 10 years of residency in the bay. At this age the fuel's low decay heat generation allows for adequate cooling by air. The movement of fuel to dry storage should be a focus by the utilities by removing fuel as soon as able based on fuel cooling needs.

8. Principle 8: Emergency Mitigating Equipment should be robust, readily available, easily deployable within required timeframes, and have adequate redundancy

Rationale:

The EME will be purchased, stored in a suitable location at or near the site and have a planned maintenance and availability testing program to ensure the equipment will operate reliably if required to address Beyond Design Basis Events. This equipment plays an important role in providing defence in depth and a credible response to BDBEs and BDBAs, including severe accidents. To ensure this equipment is able to function and meet performance requirements the following sub-principles are identified.

Emergency Mitigating Equipment Principles:

A. The EME Storage facility should be at a higher elevation and at a distance from the station to provide separation (minimize common mode event impact) but close enough to allow deployment in a timely manner.

B. The storage facility should be either a robust building which can withstand a severe external event at the Review Level Condition or a building that does not impede recovery of EME equipment by personnel if the structure is damaged by external forces.

C. EME deployment should be simple, via procedures or operating guidelines.

D. EME deployment should not be entirely reliant on specialized staff or specific work groups unless that work group has sufficient numbers to provide effective task implementation and redundancy. The rationale is to maximize the number of personnel that could execute the deployment and therefore increase the likelihood of successful deployment. It should be possible to maximize the diversity of staff who can deploy EME (i.e., staff not requiring specialized skills) using simple tasks, pre-job briefing and procedures/guidelines.

E. Training and practice should be provided to staff for the tasks they have been planned to execute.

F. EME should use proven technology as to reliability, effectiveness and run time.

G. A preventative maintenance and availability testing program should be defined and executed.

H. Unless significant benefits exist, testing of EME should be kept separate from station systems (i.e. not connected) to minimize risk of errors and equipment failures that could impact normal system operation and safety.

I. Diversity of EME deployment vehicles should not rely on one method or vehicle (e.g., delivery vehicles may include trucks, tractors and security vehicles).

J. On-site fuel supplies should be sufficient for at least 72 hour run time of EME to support all reactor units at site and IFBs.

K. It should be possible to refuel EME in place.

L. Pre-staging of EME is an option to events which may impact deployment (e.g., high winds).

M. Connections to station systems should maintain the same number of pressure boundary barriers as presently exist. For example the boiler feed system typically has an isolation valve plus a threaded cap to contain leakage for piping that allows external flow of water or steam. Any modifications to enable quick connections of EME should maintain these two barriers such as a valve and quick connect plug.

N. N. Connections should have no negative impact on the station system in terms of seismic or environmental qualification or compliance with applicable codes and standards.

9. Principle 9: Canadian utilities will use a common philosophy for the prevention of Beyond Design Basis Accidents

Rationale:

The interaction between utilities gives a larger perspective and experience base and this improves our overall decision making. The involvement of all utilities in the development and execution of our response will improve capability, provide credibility and facilitate regulatory concurrence. This method also encourages challenges and learning.

An Overview of Supercritical Water-Cooled Reactor (SCWR) Concepts

by SAHIL GUPTA[1] and IGOR PIORO[1]

[Ed. Note: The following student paper was presented at the 19th Pacific Basin Nuclear Conference (PBNC 2014), Hyatt Regency Hotel, Vancouver, British Columbia, Canada, August 24-28, 2014.]

A Master's Level Submission

Summary

Nuclear energy will play a big part in being part of the future energy mix since it offers a relatively clean, safe and reliable source of energy. Next generation nuclear energy technologies (Generation IV) are being developed around the world that offers innovative core designs and fuel cycles.

Supercritical Fluids (SCFs)[1] have been proposed for GenIV thermodynamic cycles to achieve high thermal efficiencies. Super Critical Water-Cooled Reactor (SCWR) is one of the proposed Gen IV design relying heavily on the use of SC Water for heat transfer. This abstract presents the latest developments on SCWR concepts around the world.

Introduction

The main design goals for the GenIV reactor concept are to improve thermal efficiency, enhance safety, extend sustainability, and strengthen proliferation resistance [1]. Keeping these objectives in mind, the GenIV Program has narrowed design options to six concepts: 1) Gas-cooled Fast Reactor (GFR) or High Temperature Reactor (HTR), 2) Very High Temperature Reactor (VHTR), 3) Sodium-cooled Fast Reactor (SFR), 4) Lead-cooled Fast Reactor (LFR), 5) Molten Salt Reactor (MSR), and 6) SuperCritical Water-cooled Reactor (SCWR). See Table 1 for an overview.

From Table 1, it can be seen that SCFs such as SC Water (Rankine Cycle) and SC CO_2 (Brayton Cycle) are expected to play a major role as a heat transfer medium due to their attractive thermophysical properties. Furthermore, based on the current data >90% reactors in the world are currently utilizing water as their primary coolant and as working fluid in secondary cycle[3] [2]. Thus, it is critical to develop water reactor technologies for future generations such as SCWR.

It should be noted that the use of SC Water in power cycles is not a new concept and its being extensively used in conventional thermal plants. Temperatures at the boiler exit were initially around 550°C, but recent advances in materials and turbine technology have led to units using 625°C at 25 MPa, and R&D is proceeding towards adopting outlet temperatures of over 750°C at the pressure of 35 MPa [3]. On nuclear side, Advanced Gas-cooled Reactors (AGRs) were operated successfully in UK demonstrating the feasibility of high temperature and pressure reactors with thermal cycle efficiency > 40%. There is also wide industry experience towards operations of BWR and PWR technologies. Thus, biggest attraction towards SCWR development comes from the fact that it's based upon industry proven technologies of BWR, PWR and the supercritical boiler.

The design of SCW nuclear reactors can therefore be seen as the natural and ultimate evolution of today's conventional modern light water reactors (LWRs) and heavy water reactors (HWRs). SCWR is essentially a hybrid[6] between BWR, PWR/PHWR technologies offering promising thermal efficiencies (upto 50%) and consequently economic competitiveness, sustainability and continuity of experience with water reactor technologies.

2. SCWR Design Concepts

There are a number of SCWR design concepts being proposed ranging from a Pressurized-Vessel **(PV)** type (similar to BWR/PWR), a Pressurized-channel **(PT)** type (similar to CANDU/PHWR type), or a hybrid design. The overall design approach is to match the reactor core operating conditions to those of existing supercritical turbines (from fossil fuel industry), avoiding the need for a new turbine and secondary cycle development effort[7]. Therefore, the typical outlet temperatures of the

1 Faculty of Energy Systems and Nuclear Science University of Ontario Institute of Technology (UOIT)

2 A supercritical fluid is any substance at a temperature and pressure above its critical point, where distinct liquid and gas phases do not exist.

3 Stat is based on a total of 433 Nuclear Power reactors; out of which 271 are PWRs, 83 are BWRs, and 48 are PHWR [2]

4 Most of the Gen – IV reactor concepts are looking to utilize direct thermal cycles to avoid the need for Heat Exchangers (HX). However, due to design and operational concerns limitations, indirect cycles utilizing HX are also being looked as a backup plan.

5 Utilizing Steam cycle in Sodium SFR is potentially unsafe option since piping leaks can lead to mixing of the water and sodium together which results in a violent chemical reaction. An indirect SC CO_2 Brayton cycle is safer option.

6 SCWR have direct once-through cycles (similar to BWR), while the water is in a single phase (similar to PWR) operating at extremely high temperatures and pressures.

7 Note that there are enormous capital costs associated with re-designing of secondary side of the plant and there may be limited industry interest to custom design for nuclear (due to limited market share for nuclear). Furthermore, it is wise to utilize time-tested secondary cycles and mature turbine designs to minimize investment risks.

Table 1: Overview of Generation IV Designs

System	Neutron spectrum	Coolant	Temp. Range °C	Operating Pressure MPa	Heat Transfer Cycles[4]		Thermal Efficiency %
					Primary	Alternative	
VHTR	Thermal	Helium	640 – 1000	7 – 9	Direct Brayton helium gas-turbine	Indirect gas mixture Brayton Cycle or Rankine Steam cycle	> 50
SFR	Fast	Sodium	500 – 550	~0.1	Indirect Steam Rankine[5]	Indirect SC CO_2 Brayton	40 – 42
SCWR	Thermal/ fast	Water	510 – 625	25	Direct Steam Rankine	Indirect SC Steam Rankine Cycle	
GFR or HTR	Fast	Helium	490 – 850	9	Direct Brayton helium gas-turbine	Indirect Steam Rankine cycle/ indirect SC CO_2 Brayton	~48
LFR	Fast	Lead	480 – 570	~0.1	Indirect SC CO_2 Brayton (in USA)	Indirect Steam Rankine (in Russia)	~43
MSR	Thermal/ fast	Fluoride salts	700 – 800	~0.1	Indirect Steam Rankine	Indirect SC CO_2 Brayton cycle	45 – 50

Table 2: Proposed Design Parameters for SCWR Concepts around the world

Parameters	Units	Canada	China	Europe	Japan		Korea	Russia	USA
Organization	-	AECL	SJTU	EU-JRC	Various		KAERI	OKB IPPE	INEEL
Reactor Type	-	PT	PV	PV	PV	PV	PV	PV	PV
Power (Thermal)	MW_{th}	2540	3800	2300	4039	1602	3182	3830	3575
Spectrum		Thermal	Mixed	Thermal	Thermal	Fast	Thermal	Fast-resonance	Thermal
Thermal efficiency	%	48	~44	43.5	42.7	~44		43-45	45
Operation Pressure	**MPa**	25	25	25	25	25	25	24.5	25
T_{in} coolant	**°C**	350	280	280	290	280	280	290	280
T_{out} coolant	**°C**	625	510	500	510	508	510	540	500
Flow rate	**kg/s**	1512	1927	1179	2105	820		1890	1843
Fuel	–	Pu-Th	UO_2 / MOX	UO_2	UO_2	MOX	UO_2	MOX	UO_2

SCWR designs vary from 550°C to 625°C with operating pressure around 25 MPa (also refer to Table 2).

It must be noted that while the use of high temperature and pressure fluid offers significant advantages in terms of net increase to the thermal efficiencies, it does tend to add operational and maintenance complexities. Special metallurgical considerations would also have to be made to find materials that can withstand the higher temperatures and have with minimal neutron absorption cross section area. Furthermore, high temperatures also increase the corrosion rates and may lead to an overall decrease in the operational life of the plant systems. Thus, there is a fine balance that needs to be realized in any system design involving SC water to balance the economic gains of higher efficiencies vs. the associated costs of enhanced material, operational and maintenance constraints.

3. SCWR Concepts around the world

Table 2 summarizes the various conceptual design parameters. Note that a number of these reactor concepts are still in their infancy stages and design parameters are evolving. While the reactor core and fuel designs differ significantly, there are many similarities between the secondary side cycles and safety features. Most design concepts are still facing challenges, particularly cladding material selection to withstand high temperatures during normal operations and postulated accident scenarios.

3.1 Canadian Advancements

Atomic Energy of Canada Limited (AECL) is working on the development of a PT-reactor concept, which is analogous to conventional CANDU [4]. A potential side application of the available co-generated process heat could be the extraction and refining of oil sands[8] [5] which may benefit Canada's oil sand market extensively and reduce the environmental footprint of the process. Some of the key design features of Canadian SCWR are listed below:

- **Fuel Channel Design:** It is comprised of a bundle string installed into a pressure tube insulated internally. The outer surface of the pressure tube will be in direct contact with the moderator, while the inner surface of the pressure tube is protected with a ceramic insulator to prevent the pressure tube from exposure to high-temperature coolant. In addition, a perforated stainless steel metal liner protects the insulator from damage during fuelling and/or refuelling and from erosion by the coolant flow [6].
- **Fuel Cycle:** Thorium-uranium 233 and thorium-plutonium cycles have been proposed [7] keeping the long term fuel sustainability in mind. Recent studies of thorium-based fuel cycles in contemporary CANDU reactors demonstrate the possibility for substantial reductions in natural uranium (NU) requirements of the fuel cycle via the recycle of U-233 bred from thorium [8], thus increasing the long term fuel cycle sustainability.
- **Thermodynamic Cycle:** Direct cycle is proposed and the high-pressure SCW from the core will be directly fed into the SCW turbines with operational pressure of 25 MPa and temperate of 625°C [9]. Some variants such as options for reheat channels and dual cycles (primary and secondary side) are also being considered.
- **Conceptual Core Design:** Canadian SCWR started with a horizontal core concept, however recently the direction has changed to adapt a vertical core design with separated coolant and moderator. Due to operational challenges associated with high temperatures and pressures; batch refuelling has been adopted. It is designed to generate 2540 MW of thermal power and about 1200 MW of electric power (~47% thermal efficiency). Some fuel channels at the outer region of the core could be used for the reheat option to further enhance heat utilization [10].
- **Safety System Design:** The proposed design consists of inherent safety features such as negative coolant void reactivity coefficient, separation of the primary coolant from the moderator cooling and provide passive moderator cooling system.

8 Currently, this is achieved using process heat from natural gas plants.

3.2 Chinese Advancements

A mixed core design with multi-layer fuel assembly has been proposed by the Shanghai Jiao Tong University to avoid safety and mechanical problems in both thermal and fast SCWR designs [11]. Some of the key design features of Chinese SCWR are listed below:

- **Thermodynamic Cycle:** The proposed thermodynamic cycles are based on existing PWRs and BWRs type with series of high pressure, intermediate Pressure and low pressure turbines.
- **Conceptual Core Design:** The core consists of two zones with different neutron energy spectra, one with thermal and the other with fast spectrum [12]. In the thermal spectrum (outer) zone, a co-current downward flow is applied with an exit temperature over the pseudo-critical point. The downward flow in the thermal fuel assembly will provide an effective cooling of the fuel rods and the cladding temperature will be kept at a low value. In the inner fast neutron spectrum zone a high exit temperature is achieved.
- **Fuel Assembly Design:** A multi-layered concept is proposed which divides core length into layers of different enrichment [13]. UO_2 is proposed for the Thermal spectrum while MOX is proposed for Fast spectrum.
- **Safety System Design:** The proposed design incorporates safety features from advanced water reactors relying on multiple passive systems such as gravity driven cooling systems.

3.3 European Advancements

European concepts focuses on High Performance Light Water Reactor (HPLWR) which is a PV type reactor based on thermal neutron spectrum [14]. Some of the key design features are listed below:

- **Thermodynamic Cycle:** The proposed cycle is a once-through cycle with an overall efficiency of ~44% [15].
- **Conceptual Core Design:** To avoid extremely high peak coolant temperatures, the proposed core design

consists of three pass heat-up steps with intensive coolant mixing between them to eliminate hot streaks [16]. Feedwater enters the 52 evaporator assembly clusters in the center of the core from the core bottom, through which it is heated up beyond the pseudo-critical temperature [17]. After mixing in an upper mixing chamber above the core, the coolant is directed into another 52 assembly clusters with a downward flow, which build the first superheater. Coolant mixing then occurs again in an annular mixing chamber underneath the core. Final heat up to the expected core outlet temperature takes place in a second superheater formed by 52 clusters at the core periphery. The coolant leaves the reactor at 500°C through the outer part of the upper mixing chamber.

- **Fuel Assembly Design:** The fuel assembly design is designed to accommodate three pass core and it's based on the concept proposed by Hofmeister et al [18] consisting of 9 smaller assemblies with 40 fuel rods each arranged in 3x3 clusters.
- **Safety System Design:** HPLWR builds on the safety features of BWRs with enhanced containments systems, redundant feedwater pumps, large pressure suppression pool etc. Proposals are also being made for passive residual heat removal systems [19].

3.4 Japanese Advancements

Japanese are considering 2 potential SCWR:

a) **Thermal- Spectrum Reactor** – Yamada et al. [20] described thermal PV type concept refereed as JSCWR and the basic philosophy is to build upon the proven LWR and SC fossil-fired power plant technologies as much as possible to minimize the R&D costs, time and risks.
   - **Conceptual Core Design:** The core design is similar to traditional PWR with enriched U235 as a fuel and control rods used for primary reactivity control.
   - **Fuel Assembly Design:** The JSCWR fuel assembly consist of 192 fuel rods and square moderator rod in the centre. The fuel rods contain UO_2 similar to LWR fuels in a modified stainless-steel cladding and are arranged in 16x16 square lattices [21].

b) **Fast Spectrum Reactor:** Nakatsuka et al. [22] describe the core design of fast reactor which is also based on a PV type design.
   - **Conceptual Core Design:** The core consists of seed and blanket fuel assemblies with reflectors at the periphery arranged in a PV type core [23]. A part of the feedwater flows to the top dome and then downward through the blanket assemblies of the core.
   - **Fuel Assembly Design:** In the fuel rod and core designs, MOX fuel and stainless steel cladding are used for seed fuel rods, and depleted UO_2 and stainless steel cladding are used for blanket fuel rods [22].

- **Thermodynamic Cycle:** It consists of a once-through direct Rankine cycle with ~43% efficiency. Reactor coolant fed through inlet nozzles is heated up in the core and flows through outlet nozzles with no recirculation in the vessel.
- **Safety System Designs:** Safety systems philosophy for both concepts is based upon proven LWRs concepts. The inherent safety features include negative void, Doppler coefficients, automatic depressurization systems, auxiliary feedwater systems etc. [24].

3.5 Korean Advancements

Korean SCWR concept is based on a solid moderator concept to avoid the need for complex designs for additional neutron moderation[9]. A conceptual design for 1400 MWe SCWR core with a cruciform type of U/ZrH_2 solid moderator has been studied by Bae et al. [25].

- **Thermodynamic Cycle:** Thermal efficiencies of various thermodynamic cycles design options were evaluated by Bae and Kang [26] and a direct cycle was proposed with maximum performance of ~43%.
- **Conceptual Core Design:** The Korean Atomic Energy Research Institute (KAERI) SCWR core concept is similar to conventional PWR PV type and contains 193 fuel assemblies with a four-batch fuel loading strategy. Control rods driving mechanism is located at the top of the core.
- **Fuel Assembly Design:** The fuel assembly is composed of 300 fuel rods, 25 cruciform-type solid moderator pins and 16 single pins of the solid moderator in a 21x21 array.
- **Safety System Design:** Safety systems design philosophy is consistent with the GEN-IV objectives with multiple redundant and passive safety systems.

3.6 Russian Advancements

Conceptual designs of a VVER-SCP PV type SCWR are being developed with thermal, mixed and fast neutron spectrums in Russia [27]. A single loop reactor plant based on supercritical parameters is under development [28; 29].

- **Thermodynamic Cycle:** 1600 MW cycle is proposed with once through cycle. The feedwater temperature is 280°C, and the average core outlet coolant temperature is 540°C at 24.5 MPa with efficiencies upto 45%.
- **Conceptual Core Design:** Core is a PV type and conceptual designs have been proposed for a single pass coolant and a double pass coolant flows consisting of a jacketed heaxahedral Fuel Assembly.
- **Fuel Assembly Design:** Several versions of fuel assembly designs are being developed dependent upon core designs and neutron spectrum. Basic features include a

9 In SCWR additional moderation is required to compensate the low coolant density in the later stage of coolant heat-up.

jacket tube, guide tubes for Control absorber rods, elements to create the neutron spectrum using zirconium hydride, spacer elements and structural components.

- **Safety System Design:** Safety systems consists of passive residual heat removals, emergency core cooling systems, reactor inventory makeup systems, pressure relief systems using sprays, etc.

4. Conclusions

- >90% reactors in the world are currently utilizing water as their primary coolant and as working fluid in secondary cycle. It is critical to develop next generation water-cooled reactor technologies for continued sustainability of nuclear industry.
- Supercritical Fluids will play a significant role in GenIV technology. Thermal efficiencies of up to 50% may be achieved by their use.
- SCWR is the natural evolution of LWR and HWR technology and several SCWR design concepts under development around the world. PT and PV are the main types of SCWR. Canada is pursuing development of PT type SCWR, while majority of the countries are focusing their R&D efforts on PV type SCWR. There are many variants of PV type reactors under development with innovative fuel and core design concepts.
- All SCWR concepts are proposing to utilize the direct thermal cycle with operating pressures ~25 MPa; inlet fluid temperatures ~280°C to 350°C; thermal powers from 1600 to 4000 MW.
- Economic gains realized from higher thermal efficiencies must be balanced against the increased corrosion rates, enhanced metallurgical, operations, and maintenance requirements while considering the overall system design of the SCWR.

5. References

[1] "Charter of the Generation IV International Forum", Generation IV International Forum Document (www.gen-4.org/PDFs/GIFcharter.pdf), 2002 February.

[2] Nuclear News, 2013, March, A Publication of the American Nuclear Society (ANS), pp. 47-78.

[3] *Department of Energy* (DOE), 2009. Materials for Ultra-Supercritical Steam Turbines, ORNL and NETL (www.ms.ornl.gov), and Ultra Supercritical Steam Corrosion, G. Holcomb et al., (www.osti.gov)

[4] Yetisir, M., Diamond, W., Leung, L.K.H., Martin, D. and Duffey, R., 2011, "Conceptual Mechanical Design for A Pressure-Tube Type Supercritical Water-Cooled Reactor", Proc. 5th Int. Sym. SCWR (ISSCWR-5), Vancouver, British Columbia, Canada, March 13-16.

[5] Duffey, R.B. et al., 2003. "Nuclear Energy for Oil Sands Production: Providing Security of Energy and Hydrogen Supply at Economic Cost", Proc. IAEA-CN-/108/5P, IAEA International Conference, Vienna, June.

[6] Chow, C.K. and Khartabil, H., 2007. "Conceptual Fuel Channel Designs for CANDU - SCWR", Proc. 3rd International Symposium on SCWR - Design and Technology, Shanghai, China, March 12-15.

[7] Magill, M., Pencer, J., Pratt, R., Young, W., Edwards, G.W.R. and Hyland, B., 2011. "Thorium Fuel Cycles in the CANDU Supercritical Water Reactor", Proc. 5th Int. Sym. SCWR (ISSCWR-5), Vancouver, British Columbia, Canada, March 13-16.

[8] Hyland, B., Dyck, G.R., Edwards, G.W.R. and Magill, M., 2009. "Homogeneous Thorium Fuel Cycles in CANDU Reactors", Proc. Global, Paris, France, September 6-11.

[9] Pioro, I.L. et al., 2008. "Supercritical Water-Cooled Nuclear Reactors: Thermodynamic-Cycles Options", Proc. 6th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics (HEFAT-2008), Pretoria, South Africa, Paper #PI1, June 30-July 02.

[10] McDonald, M.H., Hyland, B., Hamilton, H., Leung, L.K.H., Onder, N., Pencer, J. and Xu, R., 2011. "Pre-Conceptual Fuel Design Concepts For the Canadian Super Critical Water-Cooled Reactor", Proc. 5th Int. Sym. SCWR (ISSCWR-5), Vancouver, British Columbia, Canada, March 13-16.

[11] Cheng, X., Liu, X.J. and Yang, Y.H., 2007. "A Mixed Core for Supercritical Water-cooled Reactors", Nuclear Engineering and Technology, 40(2), pp. 117-126.

[12] Liu, X.J., Yang, T. and Cheng, X., 2010. "Core and Sub-channel Analysis of SCWR with Mixed Spectrum Core", Proc. ICAPP'10, San Diego, CA, USA, Paper 10032, June 13-17.

[13] Yang, T., Liu, X.J. and Cheng, X., 2010, "Optimization for Fast Multilayer Fuel Assemblies of Mixed Supercritical Water-cooled Reactors", Proc. 8th International Topical Meeting on Nuclear Thermal-Hydraulics, Operation and Safety (NUTHOS-8), Shanghai, China, October 10-14.

[14] Schulenberg, T., Starflinger, J., Marsault, P., Bittermann, D., Maraczy, C., Laurien, E., Lycklama, J.A., Anglart, H., Andreani, M., Ruzickova, M. and Heikinheimo, L., 2009, "European Supercritical Water Cooled Reactor", FISA, Prague, Czech Republic, June 22-24.

[15] Brandauer, M., Schlagenhaufer, M. and Schulenberg, T., 2009. "Steam Cycle Optimization for the HPLWR", Proc. 4th International Symposium on Supercritical Water-Cooled Reactors, Heidelberg, Germany, Paper No. 36, March 8-11.

[16] Schulenberg, T., Starflinger, J. and Heinecke, J., 2008, "Three Pass Core Design Proposal for a High Performance Light Water Reactor", Progress in Nuclear Energy, 50, pp. 526-531.

[17] Koehly, C., Schulenberg T. and Starflinger J., 2009. "Design Concept of the HPLWR Moderator Flow Path", Proc. 2009 International Conference on Advanced Power Plant (ICAPP'09), Tokyo, Japan, May 10-14.

[18] Hofmeister, J., Waata, C., Starflinger, J., Schulenberg, T. and Laurien, E., 2007. "Fuel Assembly Design Study for a Reactor with Supercritical Water", Nuclear Engineering and Design, 237, pp. 1513–1521.

[19] de Marsac, B., Schulenberg, T. and Schlagenhaufer, M., 2008. "Residual Heat Removal System of the HPLWR", Proc. International Students Workshop on High Performance Light Water Reactors, Karlsruhe, Germany, March 31-April 3.

[20] Yamada, K., Sakurai, S., Asanuma, Y., Hamazaki, R., Ishiwatari, Y. and Kitoh, K., 2011, "Overview of the

Japanese SCWR Concept Developed under the GIF Collaboration", Proc. 5th International Symposium on Supercritical Water-Cooled Reactors (ISSCWR-5), Vancouver, British Columbia, Canada, March 13-16.

[21] Sakurai, S. et al., 2011. "Japanese SCWR Fuel and Core Design Study", Proc. 5th International Symposium on Supercritical Water-Cooled Reactors, Vancouver, Canada, March 13-17.

[22] Nakatsuka, T., Oka, Y., Ishiwatari, Y., Ikejiri, S., Okumura, K., Nagasaki, S., Tezuka, K., Mori, H., Ezato, K., Akasaka, N., Nakazono, Y., Sasaki, K., Terai, T., Muroya, Y. and Yamakawa, M., 2010. "Current Status of Research and Development of Supercritical Water-Cooled Fast Reactor (Super Fast Reactor) in Japan", Proc. IAEA Technical Meeting on Heat Transfer, Thermal-Hydraulics and System Design for Super-Critical Water-Cooled Reactors, Pisa, Italy, July 5-8.

[23] Ju, H. et al., 2009. "Core Design and Fuel Rod Analyses of a Super Fast Reactor with High Power Density", Proc. 2009 International Conference on Advanced Power Plant (ICAPP'09), Shinjuku, Tokyo, Japan, Paper 9264, May 10-14.

[24] Ishiwatari, Y. et al., 2011. "Safety Analysis of JSCWR", Proc. 5th International Symposium on Supercritical Water-Cooled Reactors, Vancouver, Canada, March 13-17.

[25] Bae, K. M., Joo, H.K. and Bae, Y.Y., 2007. "Conceptual Design of a 1400 MWe Supercritical Water Cooled Reactor Core with a Cruciform Type U/Zr Solid Moderator", Proc. 2007 International Conference on Advanced Power Plant (ICAPP'07), France, Paper 7502, May 13-18.

[26] Bae, Y.Y. and Kang, H.O., 2003. "Thermo-Hydraulic Study of Supercritical Pressure Water-Cooled Reactor Options", Proc. 2003 International Conference on Advanced Power Plant (ICAPP'03), Córdoba, Spain, Paper 3223, May 4-7.

[27] Ryzhov, S. B., Mokhov, V.A., Nikitenko, M.P., Podshibyakin, A.K., Schekin, I.G., Churkin, A.N., 2010. Advanced designs of VVER reactor plant, The 8th International Topical Meeting on Nuclear Thermal-Hydraulics, Operation and Safety (NUTHOS-8), October 10-14, Shanghai, China, Paper N8P0184.

[28] Dragunov Yu, G., Ryzhov, S.B. and Nikitenko, M.P. et al., 2007. "Water- Cooled Reactors with Supercritical Parameters – Advanced Reactors of the 4th Generation", Scientific Transactions, MIFI-2007, Moscow, Russia, Volume 8, pp. 34–35.

[29] Ryzhov, S. B., Kirillov, P. L. et al., 2011. Concept of a Single-Circuit RP with Vessel Type Supercritical Water-Cooled Reactor, Proc. ISSCWR-5, Vancouver, Canada, March 13-16.

Nuclear Energy in the Oil Sands

by JAMES E. ARSENAULT, P.Eng.

1. Introduction

The major Canadian oil sands are located in Alberta and Saskatchewan, shown in Figure 1, with most production from the strata along the Athabaska River in Alberta. The economically recoverable oil sands reserves are estimated to be 168 billion barrels which at a current production rate of 1.8 million barrels per day (2012), are projected to last a very long time [CAPP, 2013].

Canada has been blessed with vast energy resources which make it potentially energy-independent and able to provide significant exports but there are concerns that their development cannot be managed in a wholly acceptable manner. Comparable concerns have been applied to nuclear energy in the past and in recent times to the oil sands. The technologies associated with these energy sources have always been controversial because they are at the confluence of economics and politics where finding a balance between risk and reward is difficult. So it should be no surprise that when these technologies get linked together in certain proposals their prospect for success is doubly difficult.

The possible use of nuclear energy for production of oil from the oil sands dates back to the late 1950s, when an experiment to mine the oil by detonating an underground nuclear device was proposed. It was predicted that the heat and pressure released from such a device would create a large cavern into which oil would flow, and from where it would be pumped to the surface.

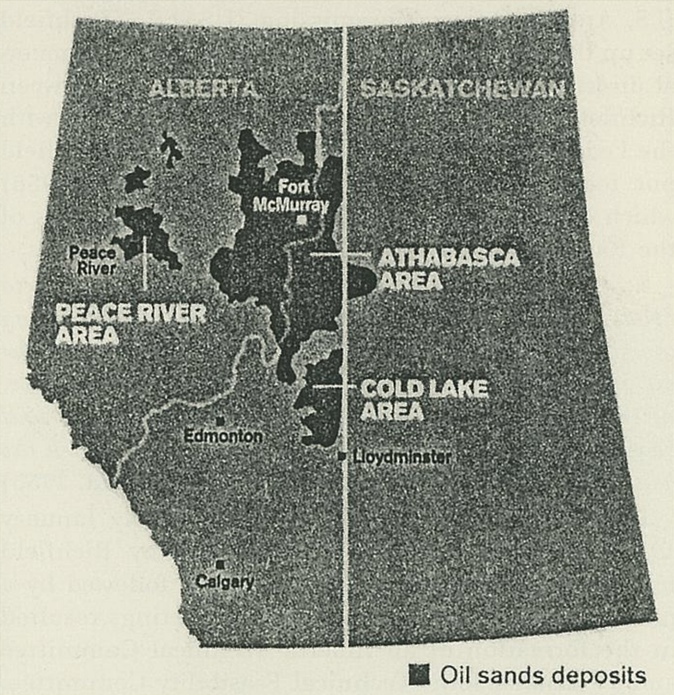


Figure 1: Oil sands Location

Almost at the same time, oil sands research using conventional sources of energy had culminated with the development of practical refining processes, essentially those still in use today. These methods require large amounts of heat energy in the form of hot water and steam. In this century nuclear energy was proposed as the source for the heat required by the oil sands production processes.

To date neither of these nuclear proposals for oil sands projects have been successful, because the economic and political balance could not be struck.

2. Oil Sands Discovery and Early Research

Alexander Mackenzie, the great fur trader-explorer, was the first European to see and record the existence of the Athabaska oil sands, as follows:

"At about twenty-four miles from the fork (of the Athabaska and Clearwater rivers), are some bituminous fountains, into which a pole of twenty feet may be inserted without the least resistance. The bitumen is in a fluid state, and when mixed with gum, or the resinous substance is collected from the spruce fir, serves to gum the canoes. In its heated state it emits a smell like that of sea-coal." [Mackenzie, 1801]

Today Fort McMurray is located at the fork of the Athabaska and Clearwater Rivers. Although the precise date is not given in his journal, the earliest it could have been is late 1787 when Mackenzie was tasked to replace Peter Pond as manager of the North West Company's Athabaska District [Hayes, 2003]. Thereafter the oil sands remained mostly of geological interest, however, many wells were drilled from the mid-1890s to the early 1920s on the assumption that the oil must be organized into underground pools. This was proven not to be the case and attention focused on separation methods. In 1921 Dr Carl Clark, a researcher with the newly formed Scientific and Industrial Research Council of Alberta, worked out a practical way of separating the bitumen from the sand using hot water. This was predicated on the fact that oil-sand material consists of about 73% sand, 12% bitumen, 10% clay, and 5% water, as in Figure 2, [Biello, 2013] and when mixed with hot water bitumen floats and sand and clay precipitate out. With this breakthrough government research continued and several commercial ventures set up plants to produce oil in small quantities. Finally in 1947 a large-scale pilot plant was completed at Bitumont, 60 km north of Fort McMurray, and was operated by the Alberta government for several years. It produced 500 barrels a day. A second plant started in 1951, which used a separation process comparable to that in use today. It proved that the application of sound engineering principles could separate oil over an extended period of time [Ferguson, 1985].

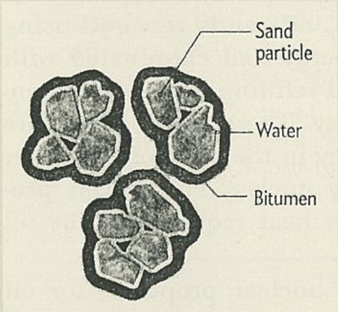


Figure 2: Oil Sands Constituents

Out of these efforts came a report in 1951 by the Alberta government which indicated that production from the oil sands could be a profitable venture at full scale [Ferguson, 1985]. However, at the time the more accessible Alberta conventional oil held the interest of the large oil companies and many years would pass until their attention turned north to the oil sands.

3. Peaceful Uses of Atomic Energy

In 1953 public attention was moved toward peaceful uses for atomic energy by a speech given by President Eisenhower of the United States (U.S.), entitled 'Atoms for Peace'. In particular, previously classified aspects of the atomic energy test program pursued by the US after World War II were to became declassified. As a result, some very imaginative scientists proposed the use of peaceful nuclear explosions (PNEs) for excavations, mineral recovery, storage cavities and petroleum recovery [Paris, 1958]. A leading proponent for PNEs was the Lawrence Livermore National Laboratory, part of the University of California Radiation Laboratory (UCRL), which was founded in 1952. It was the originator of Project Plowshare, later adopted by the U.S. to became Operation Plowshare, which encompassed the various applications of PNEs.

A series of tests conducted in 1957 was known as Operation Plumbbob and involved 29 tests of which four were underground. One of these underground tests was named Rainier and was set off in September (yield 1.7 kt) and some of the conclusions drawn were, a) radioactive products can be contained completely in underground explosions, b) depth of burial for containment is proportional to the cube root of the yield, c) seismic effects were negligible, and d) practically all of the fission products are trapped in fused rock [Johnson et al, 1958]. Figure 3 depicts the detonation zone progression.

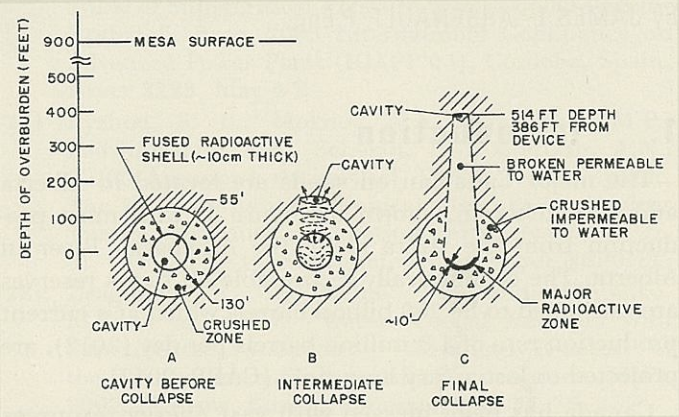


Figure 3: Rainier Detonation Zone Progression

4. PNEs in the Oil Sands

By this time the size of the reserves represented by the oil sands were generally known and their importance as an energy source was understood but plans for their wholesale development had progressed little. Dr. M.L. Natland, on the staff at Richfield Oil of Los Angeles which had interests in the Athabaska area, understood that the combined potential of the oil sands and the PNEs for mining oil could present a practical approach for their development [Marsden, 2007]. After discussions with the Lawrence Livermore Laboratory and the U.S. Atomic Energy Commission (USAEC), Richfield set up the McMurray Oil Sand Project under the general direction of Natland. Discussions followed between Richfield and the Alberta government and later with the Federal government in June 1958. In July Richfield put together a summary document [Natland, 1958] which outlined a methodology based on the results of the Rainier test for mining the oil sands with PNEs.

"*...A nuclear explosive device of sufficient caliber to produce the amount of desired heat without rupturing the surface will be placed in the lower boundary of the oil sand which is about 1200 feet below the surface. After the device has been detonated, recovery holes will be drilled surrounding the blast point through which the heated oil will be drawn to the surface.*" [Natland, 1958]

Things kept moving forward and in early January 1959 there was a formal presentation by Richfield to the Alberta Premier, E.C. Manning, followed by a press conference in February. These meetings resulted in the formation of an Alberta Technical Committee and a National Joint Technical Feasibility Committee. In May the first meeting of the National Committee involved travel to Nevada (AEC Test Facility) and California (UCRL). A timetable was set such that all required technical studies involving physical, chemical and radiological aspects were to be completed by August 1959. Most of the work was completed by Richfield in July, in a voluminous report including nine Exhibits [Natland, 1959], for an experiment on the use of PNEs for mining the oil sands, which became known as Project Oil Sands.

5. The Experiment

Richfield Oil had over the years built up considerable knowledge about the geology of the Fort McMurray area based on their own exploratory well results and from over 1000 wells drilled by others. The maps in their proposal from 1959 agree to a large extent with contemporary geological maps [Jackson, 1981].

The location chosen for the test shot was in an area previously drilled by Richfield about 96 km south of Fort McMurray and about 10 km from the Northern Alberta Railway siding of Chard, where there also was an airstrip. Today the area around Chard has become the hamlet of Janvier, with a population of about 200. More specifically the test site was between Pony Creek No.1 and Pony Creek No. 2 exploratory wells. The railway, which would be useful for transportation purposes, had arrived at Waterways (near Fort McMurray) by 1920 [Bothwell, 1984] and was used by the Eldorado Mining and Refining Company to ship uranium ore from their mine at Port Radium in the Northwest Territories to the refinery in Port Hope, Ontario. Figure 4 illustrates the general concept of the proposed experiment.

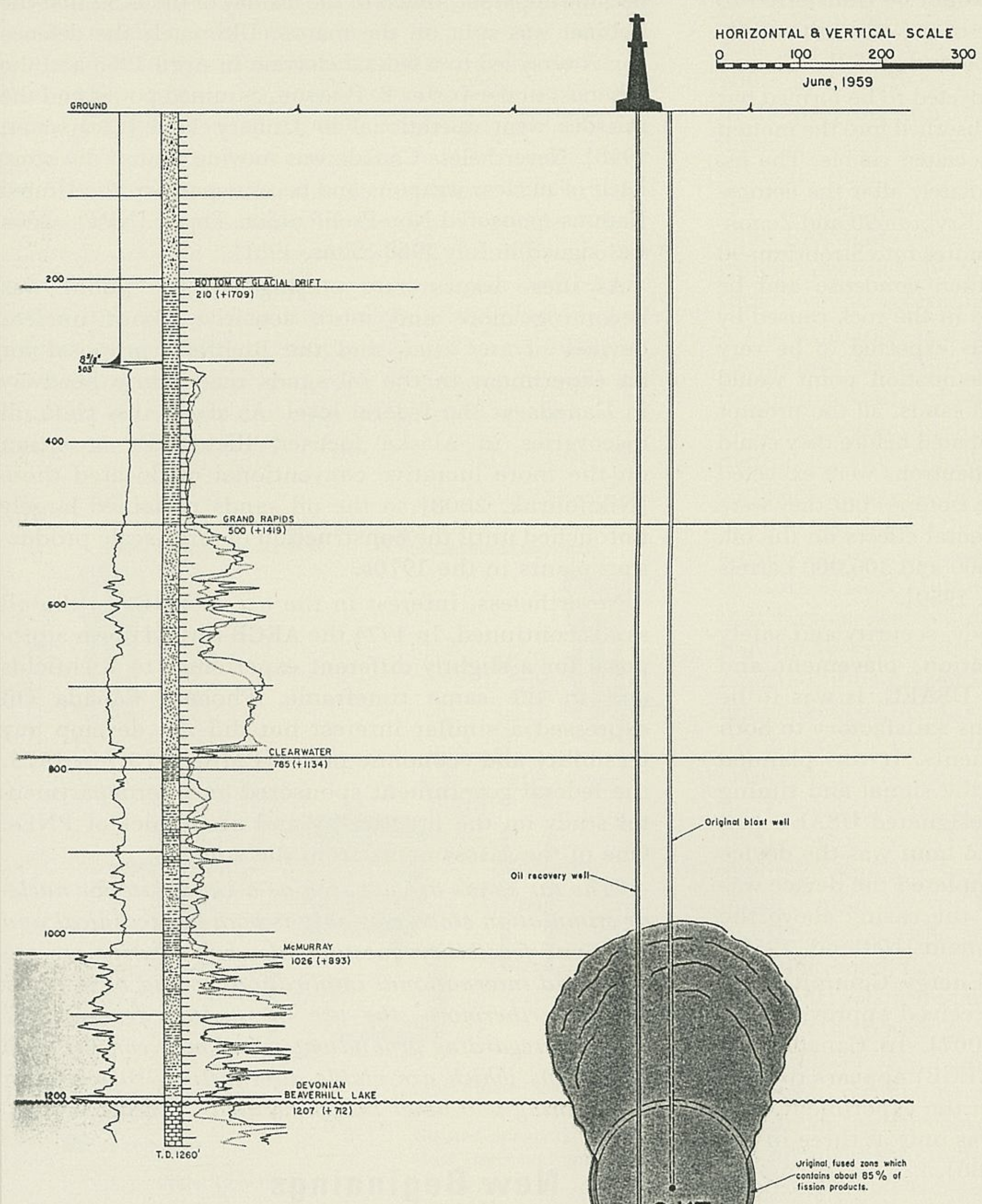


Figure 4: Cross Section Through Proposed Test Site

According to Richfield the location was selected because:

"1. The area has no surface culture, such as farms, dwellings, towns, etc., 2. There are no developed oil fields which could be disturbed by seismic effects produced by an underground detonation, 3. The mineral rights and surface rights are held under one ownership, that of the Provincial Government of Alberta, thus simplifying operational and legal matters, 4. The estimated oil in place is sufficiently large to warrant the experiment, 5. The sands are buried deep enough to permit containment of a nuclear explosion of sufficient energy yield to heat a large volume of the viscous oil to temperatures which may permit recovery, 6. The oil is of good quality, and, by processing, a wide range of petroleum products

can be derived." [Natland, 1959]

To accommodate the nuclear device, which of necessity would have a fairly large diameter of 34 inches, it was proposed to drill a hole with a 48-in diameter for about 50 ft, followed by a 38-in hole for another 1400 ft, the hole to be lined with cement for the entire length. The 1300-ft depth where the device was to be exploded would be about 100 ft below the oil sands layer and the oil was intended to drain into the cavity which it created. Using the Livermore report, it was calculated that a 9-kt device would create a 229-ft diameter cavity and would have a safe containment depth of 936 ft. The amount of energy expected to be produced was 9 trillion calories and one third to one half of this energy would be transferred to the oil sands and the temperature of the oil in the cavity would be that of boiling water [Natland, 1959].

Several fission products were expected to be formed but it was believed that they would be absorbed into the molten rock lining the cavity and the associated rubble. The fission products not absorbed immediately after the detonation were expected to be the gases Krypton-90 and Zenon-137. These gases decay in a few minutes into Strontium-90 and Caesium-137 which would then condense and be subject to adsorption ion-exchange in the rock caused by groundwater movement which was expected to be very slow. It was noted that as the detonation point would be in salty limestone below the oil sands, all the prompt neutrons released would have dissipated before they could affect the oil sand. A few delayed neutrons were expected to be present to create undesirable isotopes but they were not considered to produce detrimental effects on the oil. It was thought that between 100,000 and 300,000 barrels of oil could be produced [Natland, 1959].

Overall responsibility for custody, security and safety of the device during transportation, placement and detonation was to rest with the USAEC. It was to be transported into Canada by means satisfactory to both the Canadian and U.S. governments. It was planned that upon arrival at the site all the signal and timing circuitry would be checked by designated USAEC personnel and at no time before zero hour was the device to be armed. With all checks completed the device was to be lowered into the well and the casing above the device was to be plugged with cement [Natland, 1959].

At a hearing of the Atomic Energy Committee in March 1960, Project Oil Sand received approval from the U.S. Congress [Marsden, 2007]. In Canada, the Atomic Energy Control Board (AECB) appears to have had little or no involvement with the experiment, perhaps because the staffing level was only at three in the 1958-1959 time frame [Sims, 1980].

6. The Politics

Although the science, economics and politics for the experiment were acceptable at the provincial level, at the federal level the politics were not. In the early 1960s, bearing in mind the public sensitivity to nuclear weapons, the Conservative Diefenbaker government entered what can only be described as an indecisive phase, which inevitably went public and included the use of PNEs in Canada [Newman, 1963].

The indecision was the outcome of the North American Air/Aerospace Defence Command (NORAD) agreement, when the U.S. agreed to base two squadrons of Boeing and Michigan Aeronautical Research Center (BOMARC) missiles in Canada which were designed only to accommodate nuclear warheads [Clearwater, 1998]. When the time approached to make the missiles operational it became apparent, much to the dismay of the U.S., that the Cabinet was split on the matter. Ultimately the defence controversy led to a federal election in April 1963 and the Liberals, under Lester B. Pearson, assumed power and the missiles went operational in January 1964 [Clearwater, 1998]. Nevertheless Canada was moving toward divesting itself of nuclear weapons and became party to the United Nations-sponsored Non-Proliferation Treaty (NPT) which was signed in July 1968 [Sims, 1981].

As these issues were playing out the public was becoming more and more sensitive about nuclear devices of any kind, and the Richfield proposal for an experiment in the oil sands made little headway in Canada at the federal level. At about this time oil discoveries in Alaska focused Richfield's attention on the more lucrative conventional oil located there [Nikifouruk, 2008] so the oil sands remained largely untouched until the construction of large-scale production plants in the 1970s.

Nevertheless, interest in the use of PNEs in the oil sands continued. In 1974 the AECB turned down a proposal for a slightly different experiment to Richfields and in the same timeframe, Phoenix Canada Oil expressed a similar interest but did not develop any feasibility and economic plans [EMR, 1975]. in 1975, the federal government sponsored an interdepartmental study on the practicality and economics of PNEs. One of the assessments from the study is:

"The tar sands are not seen as a candidate for nuclear stimulation since, not only is both the technical and economic feasibility questionable, but security precautions and international implications would be a major issue. Furthermore, the use of nuclear devices pose concerns regarding groundwater and may conflict with operations which are viable alternatives, such as surface mining and other in-situ methods." [EMR, 1975]

7. New Beginnings

The Great Canadian Oil Sands (GCOS) company launched an operation in 1953 using a hot water process and had some commercial success but it was not until 1963, when Sun Oil acquired control of GCOS and agreed to build a $250M plant capable of producing 45,000 barrels per day (bpd) of crude oil, and the plant went into operation in 1967 [George, 2012]. In 1964 a group of Canadian companies incorporated to form Syncrude Canada Limited, which committed to a full-fledged facility in 1973 with a capacity of 125,000 bpd. The project officially opened in 1978 and Syncrude describes it's process as one of mining, extraction, upgrading and distribution [Agecoutay, 2003].

Originally these operations used open-pit surface mining techniques to gather the overburden, employing bucket wheels and draglines. These machines have been replaced by fleets of power shovels and trucks which are more economic and reliable to run. As most of the sands are in layers at depth, surface mining contributes only a minor percentage (about 20%) of the sands available for processing. A newer technique called Steam Assisted Gravity Drainage (SAGD) has been developed.

In SAGD two horizontal wells are drilled through the sand layer, one positioned about 5 m above the other. Steam is injected into the upper well causing the bitumen to melt and flow down to the lower well, from which it is pumped to the surface with relatively low impact on the surface environment [George, 2012].

Nevertheless, whichever type of process is used for bitumen extraction and upgrading, great quantities of energy are required.

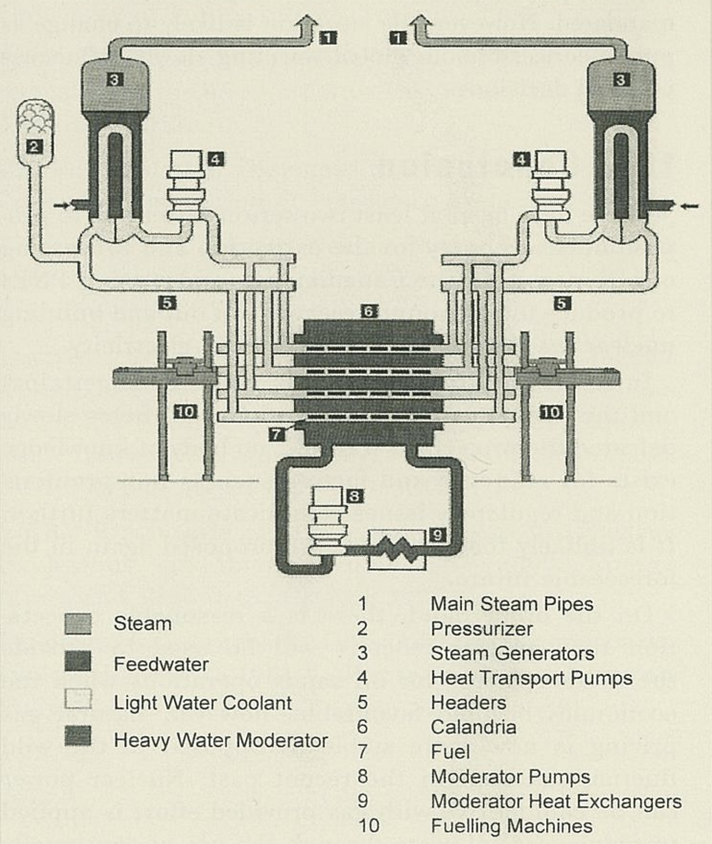


Figure 5: ACR-1000 Block Diagram

8. Energy for the Oil Sands

The province of Alberta is a net importer of electricity and in recent years the ratio of imports to exports has been about 4:1, which is not a very competitive business environment for a rapidly growing economy. The growth is expected to come from three areas, i.e., population increase, industrial expansion (primarily oil and gas), and greenhouse gas reduction requirements (substitution of coal plants with cleaner technology). The energy sources are about 45% coal and 38% natural gas which give Alberta the lead in greenhouse gas production in Canada [Bratt, 2012].

Motivated by a concern over greenhouse gas emissions from oil sand production, two successful businessmen formed Energy Alberta Corporation (EAC) in 2005, and began to promote the use of nuclear energy in the province. EAC was a shell company with no prior nuclear expertise and what it did have was acquired through discussion with outside experts, including the Atomic Energy of Canada Limited (AECL). By 2006 EAC had signed an exclusive contract with AECL which specified the sole use of the ACR-1000 reactor which was progressing through the design phase.

The ACR-1000 is a direct descendent of the Canadian Deuterium Uranium (CANDU) series with the following changes, a) light-water coolant for the fuel instead of heavy water, b) light enriched uranium instead of natural uranium, c) reduced lattice geometry for a more compact design [Doerffer, 2007]. Figure 5 is a block diagram of the ACR-1000 showing that the reactor would be a ready source of steam. The initial plan was to place the reactors at Fort McMurray but studies by AECL showed that high pressure steam could travel only 15 km and that many small reactors (less than 300 MW) would be required, thus presenting daunting economic and licensing challenges. At this juncture the plan was changed to the generation of electricity only [Bratt, 2012].

In 2007 EAC submitted a "license to prepare site" with the Canadian Nuclear Safety Commission for two ACR-1000 reactors to be located on the shore of Lac Cardinal about 27 km due west of the town of Peace River in north central Alberta. Lac Cardinal is fed by runoff from the Whitemud Hills and drains via Cardinal Creek into the Whitemud River, and then to the Peace River. In 2008 EAC was purchased by Bruce Power of Ontario. As the Alberta power system is entirely in private hands, Bruce Power saw a possible business case to become a profitable owner/operator in a field it understood well. As part of the purchase agreement, the reactor selection was opened up to include not only AECL but also Areva, GE-Hitachi and Westinghouse [Bratt, 2012].

Bruce Power proposed up to four ACR-1000 reactors but studies showed that Lac Cardinal was too shallow and would require a 35-km pipeline to the Peace River to ensure adequate cooling water. After a careful review in which

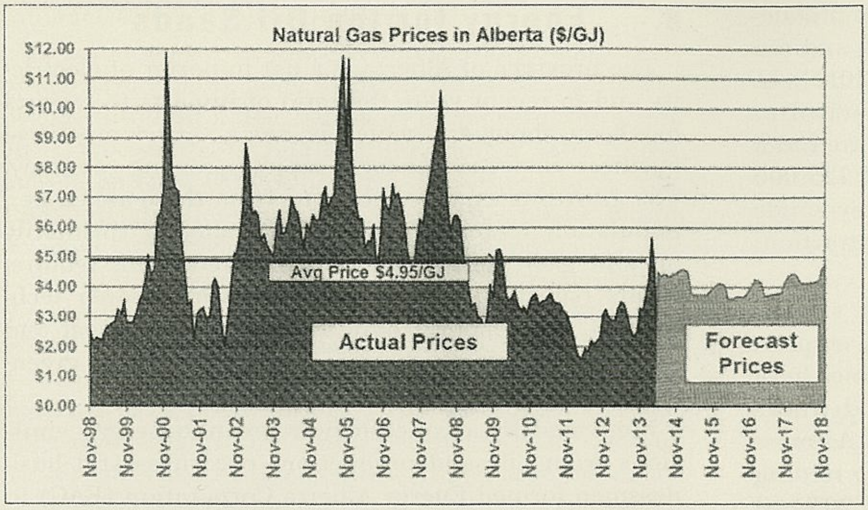


Figure 6: Natural Gas Prices in Alberta

only the Peace demonstrated adequate cooling capacity, it was decided to change the site to the Whitemud area, about 47 km downriver from the town of Peace River. Running in the background were the emerging problems of upgrading the existing electricity grid (because of age, capacity and efficiency) and how to supply electricity from Peace River to Fort McMurray, a distance of about 355 km east as the crow flies [Bratt, 2012].

It is interesting to note the connection of Alexander Mackenzie with the town of Peace River in that he established Fort Fork, just upriver at the confluence of the Peace and Smoky Rivers in 1792-1793 in preparation for his successful journey to the Pacific in 1793 [Hayes, 2001].

Because the public were becoming increasingly concerned with the use of nuclear power, the Alberta government appointed a Nuclear Power Expert Panel in 2008. It relied much on investigations by the Alberta Research Council, the Idaho Nuclear Laboratory, and public surveys in the province. In 2009 it produced a detailed report which gave nuclear power conditional support on a case-by-case basis. Despite this strong endorsement, near the end of 2011 Bruce Power decided to withdraw its proposal for a nuclear power site at Whitemud, with no explanation. However, it is clear that for a viable project Bruce Power would require a willing community, a successful environmental assessment, and a profitable business case, with the latter most likely emerging as the limiting factor [Bratt, 2012].

9. The Economics

For nuclear power to become a successful economic proposition, the cost of using nuclear power as the electricity source for heat required to extract bitumen from the oil sands must compare favourably with the cost of producing a barrel of oil using natural gas. It can be seen from Figure 6 that when EAC started up in 2005, the price of gas in Alberta peaked close to $12.00/GJ, whereas when Bruce Power shelved their plans the price had dropped to about $2.00/GJ [AEC, June 2014]. With such huge fluctuations, gas prices would seem to exhibit a total lack of the stability required for capital project economic comparisons and investment decisions. As for the future of gas prices in Alberta, they are expected to average $4.46/GJ in 2014 then drop to $3.83/GJ in 2016, before rising again to $4.56/GJ in 2019 [AEC, June 2014]. It is possible that gas prices have now reached what could be considered a stable regime but for long-term planning, they remain a somewhat risky proposition.

Studies [MIT, 2003/9] have shown that nuclear energy is an economically competitive technology compared to fossil fuels when the cost of capital is carefully managed: reducing capital risk by using continually improving standard designs, minimizing site-specific differences, and meeting defined schedules. Nuclear energy is definitely less expensive than fossil fuel energy if a reasonable cost for greenhouse gas emission (e.g., $25/t of CO2) is considered. Although some attempts have been made to factor in these costs in the form of a carbon tax or cap-and-trade system, they have had little effect as yet on the economics of nuclear power plants, as such requirements are not mandated. However, the situation is likely to change as public concern about global warming slowly influences political decisions.

10. Conclusion

There have been at least two serious attempts to propose nuclear energy for the extraction and processing of bitumen from the Canadian oil sands: using PNEs to produce underground reservoirs of oil, and building nuclear reactors to produce heat from electricity.

In the first of these proposals, political uncertainty and the opening of new conventional oil fields slowly defeated the project. As a result, no body of knowledge exists for reference and factors such as non-proliferation and regulatory issues complicate matters further. It is unlikely that PNEs will be proposed again in the foreseeable future.

On the other hand, there is a reasonable expectation that nuclear reactors will be used to provide the needed energy for oil sands operations when the economics become favourable, however, natural gas pricing is now more stable as opposed to the wild fluctuations seen in the recent past. Nuclear power can be competitive with gas provided effort is applied to reduce capital costs through the use of continually improved standard designs, minimized site-specific costs, and meeting defined schedules. The nuclear energy option becomes more attractive when reasonable costs are assigned to greenhouse gas emissions and, as the world moves more toward emission regulation, carbon taxes, and cap-and-trade systems, this option may become much more viable.

11. Acknowledgements

I would like to thank Louise Madaire for bringing my attention to the Richfield Experiment and leading me to the related original sources. Thanks to Fred Boyd for providing a copy of the Energy Mines and Resources Intergovernmental Report on PNEs. Lyn Arsenault performed her usual high-quality editorial work and additionally much improved the original drafts.

12. References

AEC. "Alberta Natural Gas Prices for the Following Year". Alberta Energy Company. June 2014. www.gas.alberta.com/pricing-market.htm. Accessed 25 June 2014.

Agecoutay, L. (ed.). Syncrude Fact Book. Syncrude Canada Limited, Fort McMurray, Alberta. 2003.

Biello, D. "Greenhouse Goo". Scientific American, Vol. 309, No.1, p. 56-61. 2013.

Bothwell, R.E. Canada's National Uranium Company. University of Toronto Press, Toronto. 1984.

Bratt, D. Canada: the provinces and the global nuclear revival. McGill-Queen's University Press, Kingston & Montreal. 2012.

CAPP. "Upstream Dialogue; the facts on oil sands". Canadian Association of Petroleum Producers. 2013.

Clearwater, J. Canadian Nuclear Weapons; the untold story of Canada's cold war arsenal. Dundurn Press, Toronto. 1998.

Doerffer, S.S. Advanced CANDU Reactor ACR-1000 Design Overview. Atomic Energy of Canada Ltd., Seminar on CANDU Technology, IGEOS, Warsaw, Poland. January 2007. www.igeos.pl/doc/2007/ 01CANDU/materialy/ACR1000/pdf. Accessed 29 June 2014.

EMR. "Practicality and Economics of Peaceful Nuclear Explosions: an intergovernmental study". Energy Mines and Resources, Ottawa. 1975.

Ferguson, B.G. Athabaska Oil Sands: northern resource exploration 1825-1951. Alberta Culture/Canadian Plains Research Centre, Regina, Saskatchewan. 1985.

George, R. Sun Rise: Suncor, the oil sands and the future of energy. HarperCollins Publishers Limited, Toronto. 2012.

Hayes, D. First Crossing: Alexander Mackenzie, his expedition across north America, and the opening of the continent. Douglas & McIntyre, Vancouver/Toronto. 2003.

Jackson, P. Geological Highway Map of Alberta. The Canadian Society of Petroleum Geologists, 2nd ed., Calgary, Alberta. 1981.

Johnson, G., G.T. Pelsor, R.G. Preston, and C.E. Violet. UCRL-5124, the Underground Nuclear Detonation of September 19, 1957 - Rainier-Operation Plumbbob. University of California-Livermore Site, Livermore, California. February 1958.

Mackenzie, A. Voyages from Montreal, on the River St. Laurence, through the Continent of North America, to the Frozen and Pacific Oceans, in the Years 1789 and 1793, with a Preliminary Account of the Rise, Progress, and Present State of the Fur Trade of that Country. Cadell and Davis, London, U.K., 1801; M.G. Hurtig Ltd., Edmonton, 1971.

Marsden, W. Stupid to the Last Drop; how Alberta is bringing environmental armageddon to Canada (and doesn't seem to care). Alfred A. Knopf Canada, Toronto. 2007.

MIT. The Future of Nuclear Power – an interdisciplinary study. Massachusetts Institute of Technology, 2003/9. web.mit.edu/nuclearpower. Accessed 3 June 2014.

Natland, M.L. and F.B. Tolman. McMurray Oil Sand Project: the use of nuclear energy to effect in situ recovery from the McMurray oil sands of Alberta, Canada. Richfield Oil Corporation, Los Angeles, California. July 1957.

Natland, M.L. Project Oilsand: a proposed experiment in the peaceful use of nuclear energy in the Athabaska area, Alberta, Canada. Richfield Oil Corporation, Los Angeles, California. July 1959.

Newman, P.C. Renegade in Power: the Diefenbaker years. McClelland and Stewart, Toronto. 1963.

Nikifouruk, A. Tar Sands: dirty oil and the future of a continent. Graystone Booke-Davis Suzuki Foundation, Vancouver. 2008.

Paris, L. "We'll Make the H-blast Serve Us". Monsanto Magazine. Summer 1958.

Sims, G.H.E. A History of the Atomic Energy Control Board. Minister of Supply and Services, Ottawa. 1981.

GENERAL news

(Compiled by Fred Boyd from open sources)

Chinese Firm Bids for Cernavoda

China General Nuclear (CGN) has submitted the sole non-binding bid for the contract to build two new reactors at the Cernavoda nuclear power plant in Romania.

The bid marked completion on September 8, 2014 of the first phase of the investor selection procedure run by state-owned nuclear utility Nuclearelectrica.

Nuclearelectrica has achieved a high standard of operation at units 1 and 2 and will be a minority shareholder in the project.

CGN and its subsidiary China Nuclear Power Engineering Company (CNPEC) recently signed agreements that would see them cooperate in the construction and financing of new Candu units at Romania's Cernavoda and Argentina's Atucha nuclear power plants.

CNPEC in July signed a "binding and exclusive" cooperation agreement with Candu Energy Inc, an SNC-Lavalin company, for the construction of Candu units 3 and 4 at the Cernavoda plant. Signed in Vancouver, the agreement was witnessed by senior representatives of China's National Energy Administration and Natural Resources Canada.

Romania already has two operating Candu 6 nuclear reactors, which came into service in 1996 and 2007. Combined, they are the largest power producer in the country, accounting for about 20% of Romania's energy supply. CGN and Nuclearelectrica signed a letter of intent last November for investment in and development of Cernavoda units 3 and 4.

China National Nuclear Corporation (CNNC) and Argentina's Nucleoeléctrica also signed an agreement last month, for construction of a Candu reactor at the Atucha nuclear power plant. CNNC operates two Candu 6 units at its Qinshan plant in China's Zhejiang province.

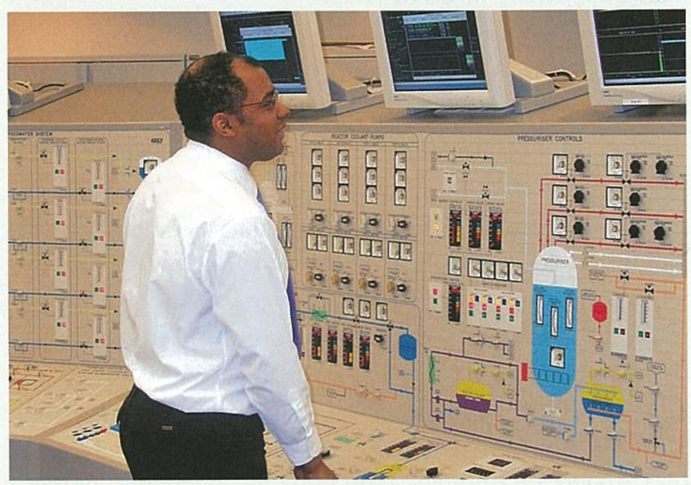
L-3 MAPPS to Enhance U.K.'s Sizewell B Simulator

L-3 MAPPS, of Montreal, has announced that it has been awarded a contract by U.K.-based EDF Energy Nuclear Generation Limited to upgrade the Sizewell B simulator and to provide a host of other training devices to support both licensed and non-licensed operations personnel. The project is underway and is expected to be completed in the third quarter of 2015.

The reactor core model will be upgraded with Orchid Core Builder to provide a higher-fidelity model, with the latest version delivering improved 2-D and 3-D visualization of the core parameters in runtime. The simulator's containment model will also be upgraded in Orchid Modeling Environment.

The enhanced simulator will be equipped with new cameras and microphones to record training sessions using Orchid Multimedia Manager, which is fully synchronized with Orchid Instructor Station. The recorded training sessions will be available for playback to critique operator actions and communication skills of the plant operators, following training exercises. The upgraded simulator will also include Orchid Sound System, which is used to generate control room sounds depending on the simulator scenario.

L-3 MAPPS will also deliver six classroom simulators to be used by the plant operators or other plant personnel to become familiar with the plant control room and its operation.



Sizewell B Power Station Simulator

USNRC Approves ESBWR

The US Nuclear Regulatory Commission (NRC) has approved GE-Hitachi Nuclear Energy's Economic Simplified Boiling-Water Reactor (ESBWR) design for use in the USA. The rule will go into effect 30 days after its publication in the Federal Register.

The NRC conducted an extensive technical evaluation of the design and issued a safety evaluation report in March 2011. The certification rule notice includes discussion of both public comments on a March 2011 proposed rule, as well as information in petitions submitted to the NRC after the Fukushima nuclear accident in Japan.

The NRC supplemented the draft certification rule in May this year to account for changes in analysis of the design's steam dryer, which prevents excess moisture from damaging a nuclear power plant's electricity-generating turbine. NRC reviewers asked for additional steam dryer information from GE-Hitachi (GEH) between 2011 and 2013. The staff's examination of that information led to the supplement, which also formally incorporated several dozen reference documents as requirements in the draft certification rule. The NRC received no comments on the supplemental rule.

GE-Hitachi Nuclear Energy submitted its application for ESBWR certification in August 2005.

The NRC is currently reviewing two combined construction and operating licence applications referencing the GEH design. Detroit Edison is seeking a licence for Fermi 3 in Monroe County, Michigan, which GEH said is expected to be issued in 2015. Dominion Virginia Power is seeking a licence for North Anna Unit 3 in Louisa County, Virginia, which GEH expects to be issued in 2016.

The ESBWR is a 1594 MWe, natural circulation reactor. The design includes passive safety features that would cool down the reactor after an accident without the need for human intervention. These passive features include enhanced natural circulation via a taller reactor vessel, a shorter core and improved water flow through the vessel; an isolation condenser system to control water levels and remove decay heat while the reactor is pressurized, and; a gravity-driven cooling system to maintain water levels when the reactor pressure has dropped.

World Nuclear News

Second Hearing on Bruce DGR Ends

The second round of Environmental Assessment hearings on Ontario Power Generation's proposed Deep Geologic Repository (DGR) at the Bruce site ended September 18, 2014 after eight days of meetings.

The original hearing was held a year by a three member Panel appointed in 2012 jointly by the Minister of the Environment (then Peter Kent) and the president of the Canadian Nuclear Safety Commission, Michael Binder. Further questions were raised, including ones about the CNSC assessment of the proposed DGR, which led the Panel to decide to continue its review. The conclusions of the Panel will not be announced for some weeks.

As background, Ontario Power Generation has processed and stored its low and intermediate level waste nuclear waste for more than 40 years at the Western Waste Management Facility (WWMF), located at the Bruce nuclear site.

In 2001, the Municipality of Kincardine requested a longterm management option. With the support of Bruce County municipalities and communities, OPG proposed to construct and operate a deep geologic repository (DGR) on its existing Bruce nuclear site, now operated by Bruce Power. The DGR would be located 680 metres below ground, in 450 million yearold, stable rock formations.

LOWLEVEL WASTE consists of minimally radioactive materials such as mop heads, rags, paper towels, floor sweepings and protective clothing used in nuclear stations during routine operation and maintenance. These items are packed in plastic bags, placed in sealed containers, and loaded onto secure transport trailers for shipping to the WWMF for processing and storage. The lowlevel waste is sorted at the facility and stored as is, compacted or incinerated.

INTERMEDIATELEVEL WASTE consists mostly of resins and filters, and used reactor components. These items are loaded into specially reinforced and shielded transportation packages certified by the Canadian Nuclear Safety Commission. Currently, this waste is also stored at the WWMF.

The CNSC video-taped the full eight days of hearings. The recordings can be accessed at the CNSC website.

Second Part of Chernobyl Arch Lifted

The second half of the Chernobyl arch has been raised in a landmark event for the long term management of the accident site.

Designed to protect the remains of Chernobyl 4, which was destroyed in an accident in 1986, the New Safe Confinement will consist of an enormous arch some 257m across and 108m high. It is being made in two large sections, the second of which has been hoisted from the ground for the first time.

After assembly on the ground, the lift to a height of 33m took place over two days on 2-4 August.

The second section consists of a number of steel frameworks, which must be extended to reach the ground before the section as a whole is complete. For the second section this is expected at the end of August,

Nearly finished, the second section is lifted in front of the first, more complete section. (Image: Chernobyl NPP) when a further lift will take it to the full height of 108m.

Once this second stage is completed, the entire structure - weighing some 31,000 tonnes - will be pushed over unit 4 and part of its turbine hall using hydraulic jacks. This sliding operation - expected to take three days - is scheduled before the end of 2015. End walls will then be built to strengthen and seal the New Safe Confinement, creating a means of confining dust and debris from the dismantlement of unit 4 while protecting it from harsh weather.

World Nuclear News

Preliminary Approval of Chinese CAP 1400 Design

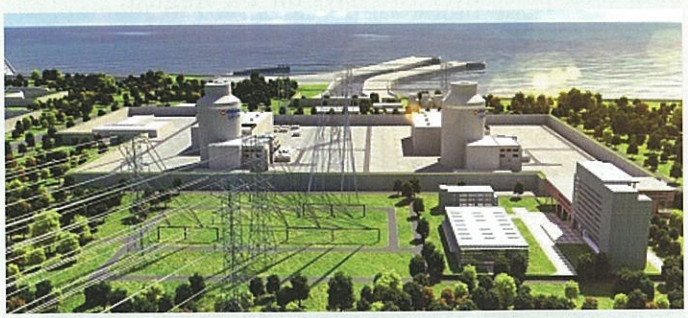
Om September 2, 2014 the Chinese National Nuclear Security Administration (NNSA) announced that it had approved the preliminary safety analysis report of the CAP1400 reactor design following a 17-month review.

The CAP1400 is an enlarged version of the AP1000 pressurized water reactor developed from the Westinghouse original by SNPTC with consulting input from the Toshiba-owned company. As one of China's 16 strategic projects under its National Science and Technology Development Plan, the CAP1400 is intended to be deployed in large numbers across the country. The reactor design may also be exported.

Site preparation is already underway for two demonstration CAP1400 units at Huaneng Group's Shidaowan site in Shandong province. The pouring of first concrete is expected to take place by the end of the year. This site is part of a larger Rongcheng Nuclear Power Industrial Park, at which the prototype HTR-PM small modular reactor is already under construction.

Huaneng is China's largest power generation company. The reactors at Shidaowan will be its first nuclear generation assets.

World Nuclear News



An artist's impression of how two CAP1400 units would look at Shidaowan (Image: SNPTC)

CNSC Approves Bruce to Operate Beyond 210,000 EFPH

Following a hearing held on September 10, 2014 in Ottawa, Ontario, the Canadian Nuclear Safety Commission (CNSC) announced its decision to approve the operation of the Bruce Power Nuclear Generating Stations Bruce B Units 5 and 6 beyond the 210,000 equivalent full power hours (EFPH) threshold.

The approval authorizes Bruce Power to operate the units, on a temporary basis, beyond 210,000 EFPH up to a maximum of 245,000 EFPH. The matter will be further considered as part of the relicensing hearings of the Bruce Nuclear Generating Station planned for January and April 2015. The Commission is satisfied that the Bruce B Units 5 and 6 can be operated safely beyond 210,000 EFPH until that time.

During the hearing, the Commission received and considered submissions from Bruce Power and CNSC staff's recommendations. The Record of Proceedings, including Reasons for Decision, is available, in both official languages, on the CNSC website.

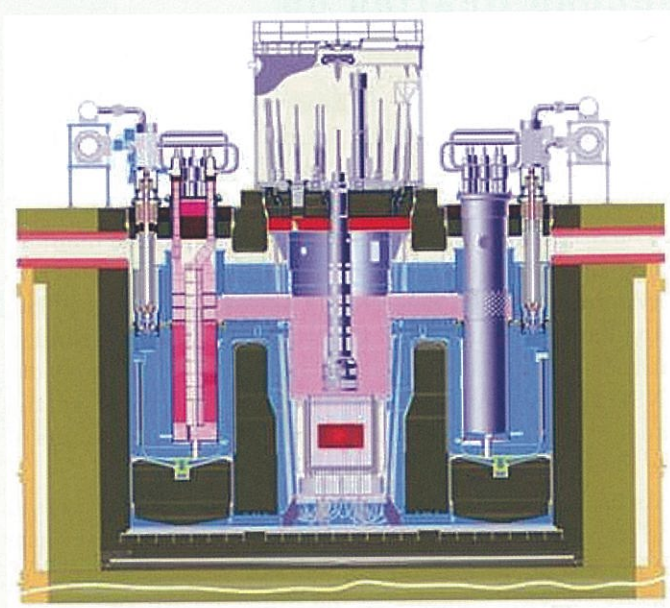
Russian Prototype Fast Reactor

Russian power engineering R&D institute NIKIET has completed the engineering design for the BREST-300 lead-cooled fast reactor.

According to NIKIET parent Rosatom, more than 25 divisions of NIKIET plus 35 other nuclear industry organizations and companies have been involved in the two-year project to complete the technical design for the prototype reactor.

The BREST reactor - standing for bystry reaktor so svintsovym teplonositelem (fast reactor with lead coolant) - is seen as a potential successor to the BN fast reactor series. In 2012, Rosatom announced plans to build a demonstration BREST-300 unit and associated fuel facilities at the Siberian Chemical Combine in Seversk, near Tomsk. Construction of the pilot fuel production plant began at the site earlier this year, and work on the reactor is scheduled to begin in 2016.

The 300 MWe demonstration unit will use dense



(Image: NIKIET)

nitride uranium-plutonium fuel with lead as the primary coolant. The inherently safe reactor would be part of a closed nuclear fuel cycle, recycling used fuel indefinitely using on-site reprocessing and associated facilities.

Longer-term plans foresee the 300 MWe unit as the forerunner to a 1200 MWe version for wide deployment as a commercial power generation unit. The development program is part of an Advanced Nuclear Technologies Federal Program 2010-2020 that seeks to exploit fast reactors as a way to be vastly more efficient in the use of uranium while 'burning' radioactive substances that otherwise would have to be disposed of as waste.

Fast reactors feature in long-term Russian plans which envisage moving to a closed fuel cycle. The BN-series of fast reactors includes the currently operating BN-600 Beloyarsk 3 unit and Beloyarsk 4, a BN-800 which started up in June and is expected to enter commercial operation in 2015. Design work is underway on the next in the series, the BN-1200.

World Nuclear News

Cosmic Rays to Pinpoint Fukushima Cores

A system using muon detectors should be able to determine the exact locations of the molten cores of the damaged Fukushima Daiichi reactors. It is to be supplied by Decision Sciences International Corporation (DSIC) through a contract awarded by Toshiba.

Middleburg, Virginia-based DSIC will design, manufacture and deliver two muon detectors that will fit into the power plant building. The detectors will be part of Toshiba's overall Fukushima Complex project to determine the location and condition of the nuclear fuel inside the plant. The value of the contract has not been disclosed.

Muons are high-energy subatomic particles that are created when cosmic rays enter Earth's upper atmosphere. These particles naturally and harmlessly strike the Earth's surface at a rate of some 10,000 muons per square meter per minute. Muon tracking devices detect and track these particles as they pass through objects. Subtle changes in the trajectory of the muons as they penetrate materials and change in direction correlate with material density. Nuclear materials such as uranium and plutonium are very dense and are therefore relatively easy to identify. DSIC has already applied the technology in its Multi-Mode Passive Detection System, used at ports for scanning containers for radioactive materials.

The 3-D image produced by the detectors should give a clear picture of the condition and location of the fuel in the cores of the three damaged reactor at Fukushima Daiichi. This will assist Toshiba in developing a safe and effective remediation plan.

Different computer models have been used by Tepco and the Japan Atomic Energy Agency to analyse the positions of the Fukushima Daiichi cores, coming to the same conclusion for unit 1. Both models predict that all 77 tonnes of the fuel from unit 1 melted and passed from the reactor vessel to the drywell area immediately below. At units 2 and 3 the models differed but together indicated that 30-40% of their 107-tonne cores remain in the vessels, the rest in the drywell.

DSIC president and CEO Stanton Sloane said, "We are delighted to extend the application of our solution to assist in the recovery of the Fukushima power plant as well as support and secure a safe working environment for personnel."

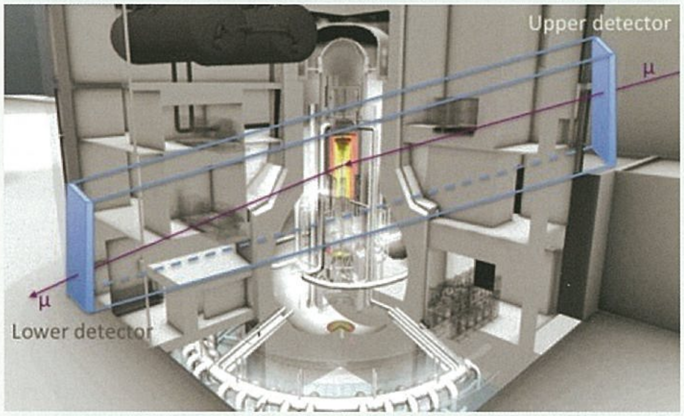
Technology Development

DSIC's muon detection system is based on technology originally invented at the Los Alamos National Laboratory (LANL).

Los Alamos chief scientist and leader of its muon tomography team Christopher Morris recently noted, "Los Alamos researchers began working on an improved method for muon radiography within weeks of the 2011 earthquake and tsunami that damaged the Fukushima reactor complex. Within 18 months we had refined our technique and published a paper showing that the Los Alamos method was superior to traditional muon radiography techniques for remotely locating and identifying nuclear materials, and that it could be employed for field use."

LANL chief technology officer Duncan McBranch said that its technology "will allow plant operators to establish the condition of reactor-core material without the need to actually get inside." He added, "Invasive techniques such as video endoscopy or introduction of robots run the risk of releasing radiation. Furthermore, those techniques at best offer a partial view of material location. Muon tomography will enable plant operators to see the location of the nuclear material inside, determine its condition, and provide critical insight that can inform the design of a safer and faster cleanup."

Researched and written by World Nuclear News



By comparing results from two detectors - one high in the building and the other low down - DSIC will be able to determine the path muons take through the reactor buildings and identify the exact location and condition of the fuel within them (Image: LANL)

Meet the President

by FRED BOYD

As President of the Canadian Nuclear Society for the 2014 – 2015 operating year, **Jacques Plourde** brings an impressive combination of senior level experience in our nuclear power industry, a long and active involvement in the CNS, and an inclusive leadership style.

On the last point he has already modified the operation of the CNS Executive and Council to make the operation of the Society smoother and more effective. As he said in his short acceptance speech at the Annual General Meeting in May, these are challenging times for the CNS. *(That speech was printed in the June 2014 issue of the CNS Bulletin.)*

His primary goal, he has expressed, is to convince the Canadian nuclear community that the Society provides significant value to the country's nuclear program and needs the support of all sectors of our nuclear community, financially and "in-kind".

Jacques comes from the Maritimes, specifically Edmundston, New Brunswick, where he was born in 1954. That background made him fully bilingual in French and English.

Following graduation from Cormier High School in Edmundston in 1972 he attended the University of New Brunswick (UNB). There he obtained a B.Sc. in Electrical Engineering in 1976 .Along the way he became introduced to the nuclear field by serving as a summer student tour guide at Atomic Energy of Canada Limited's Chalk River Laboratories (CRL).

That introduction to the nuclear field obviously captivated him. He then pursued a M.Sc. at UNB. However, most of his studies were conducted as a post-graduate student at CRL doing hybrid computer simulation of the shutdown system for the Gentilly 1 reactor. In addition he also conducted a hybrid computer simulation of a two-phase control absorber for a proposed 1250 MWe Candu.

On obtaining his M.Sc. in 1978, he joined Ontario Hydro (predecessor of Ontario Power Generation) at the Rolphton Nuclear Training Centre, located on the site of the NPD prototype station, as an Assistant Training Officer. During that period he helped introduce the use of computer-assisted training.

During 1981 – 1982 he served as an OH attached consultant at CAE Electronics in Montreal which was designing and building a simulator for the Bruce A units. That led him back to the training field as supervisor of maintenance of the Bruce A and, subsequently, Bruce B, simulators at Ontario Hydro's Western Nuclear Training Centre on the Bruce site, from 1982 to 1987.

Then he decided to join the ranks of those who operate the nuclear plants and spent the next seven years in the shift supervisor training program at the Darlington station. During that period he spent three years "co-piloting" and was involved in over-seeing the commissioning of several reactor systems. In 1994 he became officially a Shift Supervisor with specific responsibility for Darlington units 3 and 4 and for Fuel Handling.

In 1996 he was handed the challenging role of Director of the first Vacuum Building Outage. That involved overseeing more than 50 specialists dealing with the many complex and inter-active functions required to demonstrate the ability of the Vacuum Building to fulfill its function in the unlikely event of a major loss-of-coolant event.

Further management assignments followed. Jacques was appointed Section Manager, Works Management in 1997. In 2003 he became Manager, Strategic Planning and then, in 2007, as Manager, WANO and External Interface. He retired from OPG in 2010.

Following official retirement Jacques has kept busy with a number of contracts, one of which is on-going, as primary technical advisor to the Nuclear Insurance Association of Canada. This involves him in nuclear insurance surveys of all of the Canadian nuclear establishments covered by the Nuclear Insurance Act.

Although these consulting roles take much of his time, official retirement has allowed Jacques to renew his long-time interest in the Canadian Nuclear Society where he is a Charter member (meaning he joined in the first year of the Society's formation). That may be a result of his time at the Rolphton training centre which was headed by George Howey, the first President of the CNS.

He was Chair of the Darlington Branch and over the past few years Jacques has been actively working towards a restructuring of the Pickering and Darlington branches.

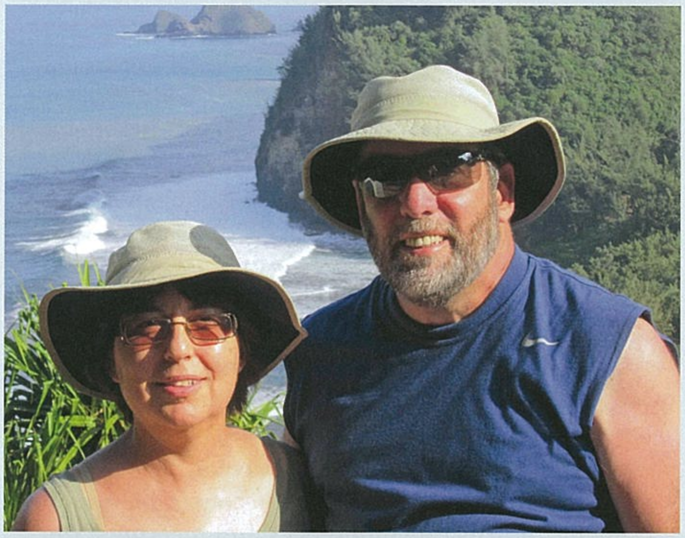
He was also Chair of the Nuclear Operations and

Maintenance Division, where he was deeply involved in major conferences, including the CANDU Maintenance Conferences of 2011 and 2014. He also launched the Operating Utility Engagement initiative to encourage renewed participation of the Utilities in CNS events.

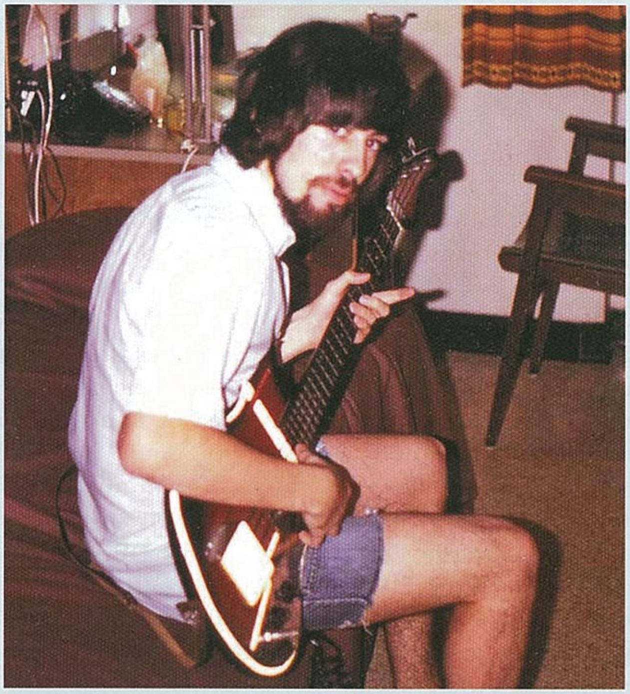
Despite this very active and full professional career Jacques has been and is still involved in a number of community activities. He has been active in Scouting since his high school days in Edmundston continuing this involvement through his moves to Deep River, Southampton (near Bruce station) and his present home, Oshawa. He also finds time to assist with various community services such as St. Vincent Kitchen, Meals on Wheels and various Francophone activities and projects in Oshawa.

At the personal level, Jacques has been married to Bernadette since 1977. They have a son Jonathan, a daughter Christine and a grand-daughter, Robyn.

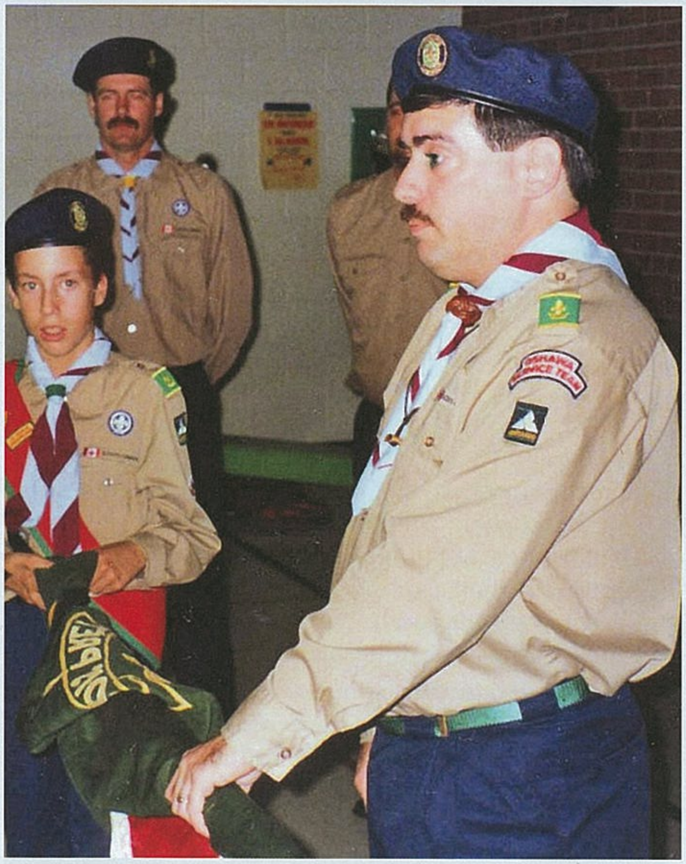
Undoubtedly, Jacques will leave a significant legacy in his year as CNS President.



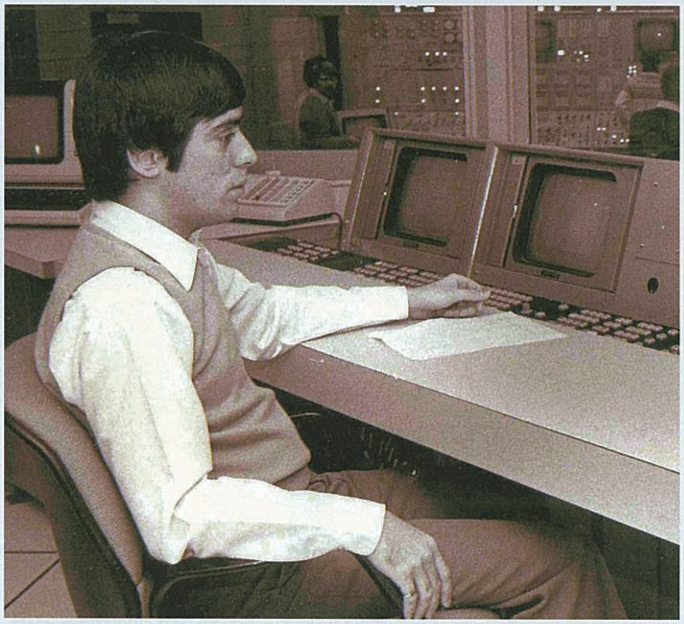
Jacques and wife Bernadette on holiday in Hawaii in early 2014.



Jacques demonstrating his musical abilities while in residence at UNB in 1976.



Jacques in his Scout uniform at a function in Oshawa 1991.



Jacques at the Bruce A control simulator during his raining period at Ontario Hydro's Western Nuclear Training Centre at the Bruce site, 1983.

Deep River Science Academy Students Redo Laurence Calculation

Back in 1940/41 George Laurence, who, 20 years later became the first full-time President of the Atomic Energy Control Board (predecessor of the CNSC) was head of the radiation section of the National Research Council. He had studied at Cambridge and was very aware of discovery of fission in1938. Although totally involved in wartime activities he decided to see if he could demonstrate the possibility of a chain reaction.

On his own time, with summer help from Bernard Sargeant, a physicist at UBC, he built an assembly of graphite (actually coke) and uranium oxide. When that was built he inserted a neutron source and measured the neutron flux in the assembly. Because of the many impurities in the materials it did not reach criticality. However Laurence measured the neutron flux at different locations in the assembly and then did the laborious hand calculation to determine the multiplication factor (k) that he had achieved.

Over 70 years later two students at the 2014 Deep River Science Academy redid the calculations using modern computer codes. Given the uncertainty of the impurities of the materials used by Laurence this meant running many calculations. They eventually concluded that the lower range of Laurence's hand calculated estimates were probably the correct ones.

On July 23, the two students, their DRSA mentor and a number of interested persons gathered in the Council chamber of the old NRC building in Ottawa to listen to the young scientists, Emily Chan and James Xu, describe their work.

CNS historian Jim Arsenault had proposed this exercise and Ruxandra Dranga of CRL (and a very active member of the CNS) convinced the organizers of the 2014 DRSA to have the young people conduct this exercise.

The DRSA students who did the review of Laurence's calculations pose after their presentation at NRC, July 23, 2014 with their mentor. L to R. DRSA students Emily Chan and James Xu with mentor Rebecca Carrington.

CNS Council Debates Future of Bulletin

At its two most recent meetings, July 11 and September 12, 2014, the CNS Council discussed the future of the CNS Bulletin.

This was precipitated by two factors, the disastrous financial results of the past two years and the announced decision from the publisher that he intended to step down after 20 years in that (voluntary) role.

At the July meeting the focus was primarily on the financial situation of the Society and the report from the publisher that commercial advertising (which had covered almost all of the cost of the Bulletin) had markedly decreased.

Over 2012 and 2013 in particular the Society ran a considerable deficit because of much smaller returns on conferences and meetings, the prime source of income. Although the CNS still has a healthy bank balance it has been recognized such losses must not continue and almost all of the sub-budgets of the Society have been cut.

Much of the discussion at the July meeting referenced digital publications concluding with the President asking Colin Hunt (who manages the publication of the Year Book) to prepare a proposal for a digital version of the Bulletin.

Colin prepared such a report which was tabled at the September meeting. His report compared the current total cost of the printed version of the Bulletin with that for a proposed digital format. The latter showed a lower cost for the digital version even with paid contractors, with the possibility of income from advertising.

Surprisingly, many around the Council table expressed their preference for the printed version. It was not unanimous and the final outcome was that a questionnaire would be developed to be sent to all members to determine in which format the Bulletin should be published.

Recognizing the complexity and delicacy of the question a small group was appointed to develop an appropriate questionnaire to be sent out by early 2015 with the objective of having a final decision by March 2015.

BRUCE – John Krane

The Bruce Branch has no current activities but is planning to host a presentation later in the fall.

CHALK RIVER – Scott Read

Speakers:

- The CNS and Deep River Science Academy (DRSA) held their annual joint lecture series for the DRSA summer students. The four talks were all extremely well attended by both the students and local CNS members. The four talks were:
  - July 10th: Jeremy Whitlock – Splitting Atoms – Canadian Style
  - July 17th: Nick Priest – The Toxicity of Radiation and the Development of Radiation Protection: Roentgen to Litvinenko
  - July 24th: Fred Boyd – The Peaceful Uses of Nuclear Explosives, A Forgotten Nuclear Program
  - July 31st: Bill Diamond – Accelerator Production of Medical Isotopes

Education and Outreach:

- The CNS-CRB sponsored two awards at this year's DRSA graduation ceremony. The two awards were for excellence in innovation and went to the students who showed great initiative with their projects and who were most likely to continue on to do research at a professional level. The award recipients were Emily Chen and Fangwei Chang, who each received a year subscription to Scientific American and $200.
  - Emily Chen's project was titled "Quantitative Analysis of George Laurence's Subcritical Pile Using Current Reactor Physics Codes"
  - Fangwei Chang's project was titled "Interatomic Potential Functions for Higher Energy Radiation Damage"

Other Initiatives:

The Peterborough Planetarium travelled to Deep River this summer to take part in Summerfest on August 2nd and 3rd. The CNS-CRB helped bring the planetarium to the public with a partial monetary sponsorship as well as provided volunteers to help run the planetarium while the shows were going on. There were 3 twenty-minute shows playing every half hour. The shows were: "Space: An Overview", "Mars!", and "Constellations in Different Cultures". Participants were in attendance for each show both days, including many that were at capacity.

DARLINGTON / PICKERING

CNS President has reported that the planned merger of the Pickering and Darlington Branches is progressing well.

GOLDEN HORSESHOE – David Girard

On July 29th, the Canadian Nuclear Society Golden Horseshoe Branch hosted a seminar titled: *"Recent Nuclear Data and Experimental Benchmarking Activities at the OECD-NEA"* was given by Ian Hill (from OECD) at McMaster University.

(The Nuclear Energy Agency (NEA) is a specialised agency within the Organisation for Economic Co-operation and Development (OECD), an intergovernmental organisation of industrialised countries based in Paris, France).

On August 22nd, the branch hosted a seminar titled: *"Managing the Fukushima Challenge"*, presented by Professor Atsuyuki Suzuki who was previously the Chair of the Nuclear Safety Commission of Japan and the President of the Japanese Atomic Energy Agency. The event was well attended with approximately 80 attendees from the nuclear community, professional engineers and the general public.

We look forward to hosting a presentation by Jeremy Whitlock at a date still to be determined..

MANITOBA Branch– Jason Martino

The Manitoba Branch.is planning to host a presentation later in the fall.

OTTAWA Branch – Ken Kirkhope

The first meeting of the Ottawa Branch for the 2014 – 2015 season will be a talk by Garry Schwarz of the CNSC on the *EU Stress Test for the Cernavoda NPP* to be held Thursday, September 25th. Jeremy Whitlock is scheduled to speak on75 years of fission on a date I October still to be decided.

SHERIDAN PARK Branch – Raj Jain

The Sheridan Park Branch held a seminar on September 11, 2014 at which Jeremy Whitlock presented his tale of *"75 years of Fission"*.

UOIT Branch – Terry Price

Fred Boyd presented his talk on *Peaceful Nuclear Explosives* on Sepember 11, 2014.

The following message has gone out to UOIT CNS Members:

On Wednesday August the 20th, we will be hosting a Nuclear Science and Energy Issues Discussion Group. This group will feature moderated discussion on various topics related to nuclear science and energy issues. Topics for discussion will be taken at the beginning of the meeting. Attendees are invited to bring in news articles or book passages that they would like to share and discuss.

This meeting will be held 7:30-9:00 pm in the ERC Atrium. Refreshments will be provided.

Sincerely,

CNS-UOIT Executive

Chair:	Terry J. Price
Vice-Chair:	Zaid Kedani
Treasurer:	Elish Modi
Secretary:	Cristina Mazza
Communications:	Patrick Dolloso, Raef Roman

WESTERN Branch – Jason Donev

Paul Hinman was awarded a much deserved outreach award, at **PBNC 2014**, which was accepted by Aaron Hinman. While this honor was awarded posthumously, the family was thrilled at the recognition from the CNS and CNA.

The following members of the CNS Western Branch attended the PBNC 2014 conference in Vancouver, August 25-28, 2014: Chary Rangacharyulu, Jerzy Szpunar, Barbara Szpunar, Neil Alexander, David Torre, Jasdeep Toor, Jaafer Khani, Riley Fedechko, Ellen Lloyd, Jasper Martin, Jason Donev, and Matthew Dalzell.

The students' posters were very well received, with Jasper Martin being the first Western Branch student to win first place in the poster competition (specifically the undergraduate category).

Jason Donev presented three papers that were well received. One paper on novel teaching methods for nuclear power, one paper was on the CNS nuclear 101 initiative. The final paper (with CNS members coauthoring: Jacqueline Williams, Braden Heffernan and James Jenden along with Ellen Lloyd and Jasdeep Toor) was on a free on-line energy encyclopedia that covers the entire energy sector. The belief is that a broad overview of energy in our society will make people more interested in the positive aspects of nuclear power. This site is now in beta testing at: energyeducation.ca. Matthew Dalzell presented a paper on the Fedoruk Centre's efforts in engaging the broader community on the impacts of nuclear research. He also co-authored a paper with **Neil Alexander** on the Fedoruk Centre's plans in the area of nuclear medicine. Papers were also presented by Branch members Chary Rangacharyulu, Jerzy Szpunar and Barbara Szpunar.

The PBNC conference was also a chance to talk with two former students (and former CNS members) Fatima Garcia and Jeff Maki. Both are now pursuing graduate studies in nuclear related fields as a result of the CNS sponsored trip to Idaho National Labs in 2009. They both wished to express their thanks to the council for providing such a wonderful and inspiring opportunity.

On September 4th, Jason Donev presented on the importance of understanding energy in our society and why nuclear power bears a closer look to the Southern Alberta Council on Public Affairs. This event was well attended and covered in both local print media and on television. Shaw TV had a 30 minute news spot showing the discussion of the importance of energy literacy and why increasing the amount of nuclear power generation should strongly be considered.

The executive is still discussing various outreach efforts.

PBNC 2014 – Technical Papers

There were 300 excellent technical papers from all of the countries involved presented at the 2014 Pacific Basin Nuclear Conference held in Vancouver, August 24-28, 2014.

They are now available for purchase through the CNS office.

The papers are grouped in four broad categories, each with sub-categories.

The website www.pbnc2014.org now contains the Program with the Abstracts.

Interested readers can surf the website and decide if they want to buy the full Proceedings of the conference or the full version of individual papers.

The files have instructions on how to get the full papers from the CNS Office.

If you have problems accessing the above website or otherwise, contact the CNS office at e-mail: cns-snc@on.aibn.com

Obituary

Lloyd Secord

Lloyd Calvin Secord, a prominent member of the Canadian nuclear industry, died in Toronto on June 24, 2014 at the age of 90.

A 1945 graduate of mechanical engineering at Queen's University he first worked for Orenda on the engine for the CF 100 jet fighter and subsequently on the Iroquois engine for the Avro Arrow.

In the early 1950s he joined with Paul Dilworth and George Meagher to form Dilworth, Secord and Meagher Associates (DSMA).. The company became active in the emerging Canadian nuclear program, especially in developments of the fuelling systems for the early CANDU reactors. It was also involved in the design of the TRIUMF cyclotron at UBC.

His active personal involvement with the nuclear program led him to be elected president of the Canadian Nuclear Association.

Among his honours he was named a member of the Order of Canada, and a Fellow of the Engineering Institute of Canada and of the Canadian Aeronautics and Space Institute.

•SAINT JOHN 2015•

Nuclear Innovation through Collaboration
La collaboration facilitant l'innovation nucléaire

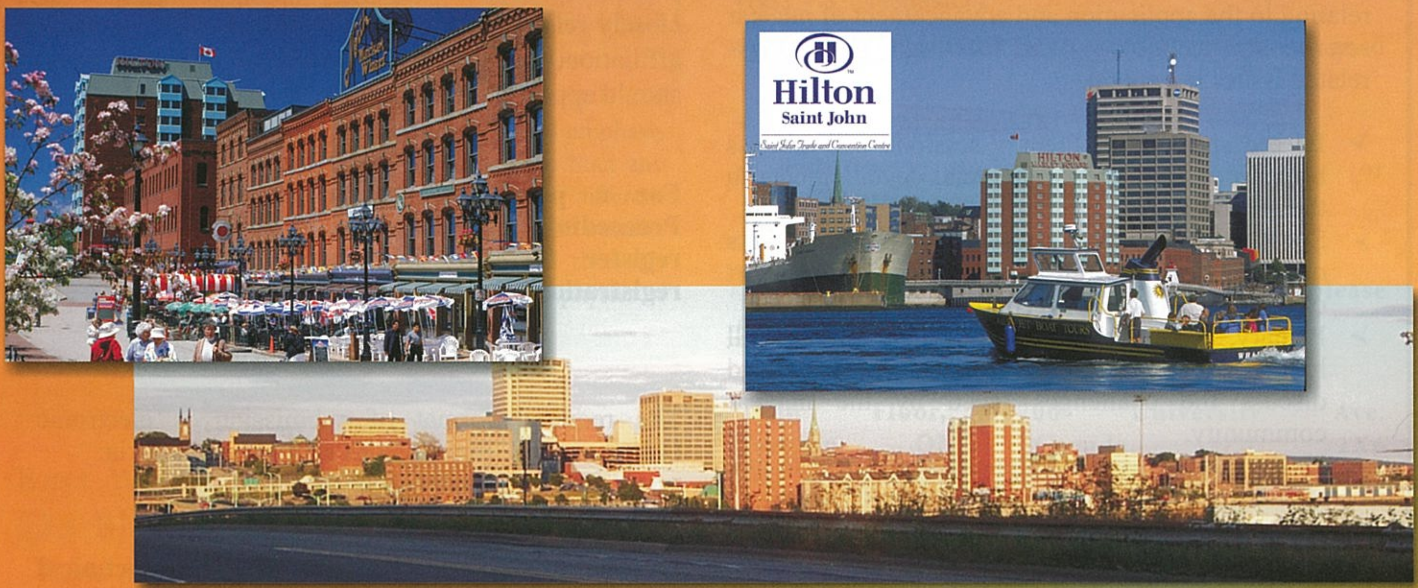
In June 2015, join us in Saint John, NB as we embrace all aspects of renewal and growth in Canada's vital nuclear science & technology sector.

CNS 2015 SNC
Saint John, N.B.

CANADIAN NUCLEAR SOCIETY ® SOCIÉTÉ NUCLÉAIRE CANADIENNE

35th Annual CNS Conference
39th CNS/CNA Student Conference
Saint John, NB • May 31 - June 3, 2015

HILTON SAINT JOHN / SAINT JOHN TRADE AND CONVENTION CENTRE



- Sponsorship and Exhibition opportunities
- Many plenary and technical sessions
- Student technical poster session
- Honours and Awards Banquet
- 2015 W.B. Lewis Lecture/Luncheon
- North American Young Generation in Nuclear Professional Workshop
- Reception, breaks, exhibits, and other networking opportunities
- Guest program: breakfast, tours, shopping, etc.

Conference Organization: Canadian Nuclear Society
Host: NB Power

www.cnsconference2015.org

35th Annual Conference of the Canadian Nuclear Society
and 39th Annual CNS/CNA Student Conference

Nuclear Innovation through Collaboration
La collaboration facilitant l'innovation nucléaire

2015 May 31-June 3
Hilton Saint John / Saint John Trade & Convention Centre, Saint John, NB, Canada

Call for Technical Papers

The Canadian Nuclear Society's 35th Annual Conference will be held in Saint John, New Brunswick, Canada, 2015 May 31-June 3, in conjunction with the 39th Annual CNS/CNA Student Conference, at the Hilton Saint John / Saint John Trade & Convention Centre.

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

- Invited speakers in Plenary sessions will address broad industrial and commercial developments in the nuclear field.
- Speakers in ***technical sessions*** will present papers on industrial, research and other work in support of nuclear science and technology.
- Plenary, technical and student sessions will highlight future developments in the field and discuss the challenges faced by the nuclear community.
- University students in Student sessions will talk about their research and academic work (a separate Call for Students' Extended Abstracts will be issued for the Student Conference).

Conference Website:
www.cnsconference2015.org

Deadlines

- **Receipt of Abstracts: 2014 November 1.**
- **Receipt of full papers: 2015 February 1.**
- **Notification of accepted paper: 2015 March 1.**

Paper abstracts (<100 words) should be submitted to the Conference Website. Please note that the abstract submission represents the author's commitment to submit a full paper on or before 2015 February 1 and, if the paper is accepted by the Conference Paper Review Committee, to present it at the Conference.

General Guidelines for Full Papers

Papers should present facts that are new and significant, or represent a state-of-the-art review. They should include enough information for a clear presentation of the topic. Usually this can be achieved in 8-12 pages, including figures and tables. The use of 12-point Times New Roman font is preferred. Proper reference should be made to all closely related published information. The name(s), affiliation(s), and contact information of the author(s) should appear below the title of the paper.

NOTE
For a paper to appear in the Conference Proceedings, at least one of the authors must register for the Conference by the "early" registration date (2015 April 15).

Paper Submission Procedure

The required format of submission is electronic (Word or pdf). Submissions should be made via:
www.softconf.com/d/CNS2015Technical

Questions regarding papers and the technical program should be sent to:

Ruxandra Dranga
CNS-2015 Technical Committee Chair
e-mail: cns2015@cns-snc.ca
Tel: 613-584-3311, Ext. 46856

General questions regarding the Conference may be addressed to:

Ben Rouben
e-mail: cns2015org@cns-snc.ca
Tel: 416-977-7620

CANDU FUEL TECHNOLOGY COURSE

2014 October 6-7

Canadian Nuclear Society Fuel Technology Division

Best Western Plus Durham Hotel

559 Bloor St. West, Oshawa

Aim of Course

The aim of this course is to provide an understanding of the CANDU fuel design, performance and operation, and how the fuel interacts with the interfacing systems. The course will be of great interest to both management and technical staff, to fuel designers, manufacturers, station operations, fuel channel and fuel handling system designers, safety analysts, performance and inspection staff.

Course Outline

This course will provide an overview of the CANDU fuel design, performance and operation, with a special emphasis on the systems that interface with it. Fuel, more than any other reactor component, interfaces with many different systems. The course will describe the design of the bundle, the detailed nuclear physics of its operation, the thermal-hydraulic performance, the fuel handling, fuel and physics of the reactor, the discharge and storage of the fuel.

HOTEL ACCOMMODATION

Best Western Plus Durham Hotel
559 Bloor St. West, Oshawa

Please make accommodation arrangements, if required, directly with the hotel at 905-723- 5271 or 1-888-247-2201. A special group rate of $109.99 + tax per night is available on the nights of October 5 & 6 if booked before 2014 September 6. Refer to "Canadian Nuclear Society Course" at time of booking. There is also a Comfort Inn next door, at a special rate of $99.99 +tax per night, if booked before September 6 at 905-434-5000.

Registration

Please register on-line via the link on the CANDU Fuel Technology Course web page, which you can reach directly at http://www.cns-snc.ca/events/2014_fuel_technology_course or via the CNS web site (http://www.cns-snc.ca).

The registration fees are shown below, and include HST (HST # 870488889RT)

- **CNS Member: $720 [Must be a CNS member in good standing]**
- **Non-CNS Member: $820**
- **Full-time student (CNS member) or CNS Retiree member: $300.**

For registration information, please communicate with:

CNS Office

**4th Floor, 700 University Ave.
Toronto, ON, Canada, M5G 1X6
Tel: 416-977-7620; Fax: 416-977-8131
e-mail: cns-snc@on.aibn.com**

Course contacts (not for registration):

Steve Palleck
Consultant, Advanced Engineering Group
GE-H Canada
Tel: (705) 748-8259
E-mail: stephen.palleck@ge.com

Erl Køhn
Consultant, Fuel Design
AMEC-NSS Tel: (416) 592-4603
E-mail: erlkohn@acanac.net

Canadian Nuclear Society
Société Nucléaire Canadienne

1st Technical Meeting on Fire Safety and Emergency Preparedness for the Nuclear Industry

Delta Meadowvale Hotel & Conference Centre
Mississauga, ON, June 17 – 19, 2015

The 1st International Meeting on Fire Safety and Emergency Preparedness will provide a forum for nuclear professionals to network and communicate changes presently impacting the industry. It is an opportune time as the new standard, CSA N393 Fire Protection for Facilities that Process, Handle or Store Nuclear Material is approved for use. This standard may affect facility licenses as early as 2014. It is expected that CSA N393 will be included in a broader range of facility licences and will replace NFPA 801 Standard for Fire Protection for Facilities Handling Radioactive Materials in existing licences.

Emergency Preparedness is at the forefront of the nuclear industry since the 9.0 magnitude earthquake and tsunami 2011 that resulted in the Fukushima nuclear incident. The CNSC has introduced REGDOC 2.10.1 Nuclear Preparedness and Response to clarify emergency preparedness requirements. This document is now in draft form and has been issued for comments.

The conference is intended to attract participants from various sectors of the nuclear industry relating to power reactors, research reactors, nuclear laboratories, mines, processing, storage and handling facilities, decommissioned nuclear facilities, nuclear medicine and transportation of nuclear materials.

FSEP 2015 – Call for Abstracts

The Technical Program Committee invites the submission of abstracts for proposed presentations pertaining to the topic areas within each of the four conference themes. Abstracts are to be no more than 300 words in length and the deadline for submission of abstracts is **December 15, 2014**. Details will be on the conference website soon, www.cns-snc.ca.

Get engaged: plan to participate as a Speaker, Session Chair or member of the Organizing Team.

Technical Focus

Business Performance and Governance	Human Performance	Technology	Processes and Programs
Regulatory Affairs	Succession Planning	Communication	Nuclear Safety
Codes & Standards	Instructional Systems Development/Training	Event Simulation	Integrating Services
License and Laws	Personnel Safety	EME	Fire Prevention
Organizational Design/Alignment	Human Resources	Fukushima	Engineering Change Control
Management Oversight	Leadership	Emerging Technologies	Business Continuity
Visions of the Future	Ethics	Analytical Tools	Risk Management
Strategies	Human Factors	Fire Protection Systems	OPEX
Business Metrics	Management of Performance Systems	Emergency Response Equipment	Analysis, Evaluation and Measurement

Conference Chair:
Tracy L. Pearce
Atomic Energy of Canada Ltd
Chalk River Laboratories
1-800-377-5995 x 44084 pearcetl@aecl.ca

Technical Chair:
Rudy Cronk
Professional Loss Control
3413 Wolfedale Road, Suite 6, Mississauga, ON
1-800-675-2755 rcronk@plcfire.com

AECL
EACL

3rd International Technical Meeting on Small Reactors "Applications of Research Reactors and Small Modular Reactors"

2014 November 5-7
Ottawa Marriott Hotel, Ottawa, Ontario CANADA

Objective

Atomic Energy of Canada Limited (AECL) and Canadian Nuclear Society (CNS) are hosting the 3rd International Technical Meeting on Small Reactors. There is growing international interest and activity in the development of small nuclear reactor technology including building prototypes and research reactors. This meeting will provide participants with an opportunity to share ideas and exchange information on new developments.

Following the success of the 2nd Technical Meeting in November 2012, which captured the achievements, capabilities, and future prospects of small reactors, this 3rd Technical Meeting is dedicated to the applications of research reactors and small modular reactors.

This Technical Meeting will cover topics of interest to designers, operators, researchers and analysts involved in the design, development and deployment of small reactors for research and power generation. A special track is planned to focus on small modular reactors (SMR) for generating electricity and process heat, particularly in small grids and remote locations.

A technical tour of the Chalk River Laboratories will be hosted by AECL for all interested attendees on November 7. It will include the ZED-2 and NRU reactors.

Topics of Interest

Presentations related to the following topics are of interest to this Technical Meeting:

- Research reactors and low power critical facilities
- Radionuclide production
- Materials research and neutron beam
- Operating experience
- Aging management
- Commercial SMRs for electricity generation
- Small reactors for remote locations and niche applications
- Safety and licensing
- Autonomous control and operation
- Reactor physics
- Thermalhydraulics and passive safety
- Advanced materials and chemistry
- Advanced fuels
- Education, training and outreach

Conference Website

www.cns-snc.ca/events/3tm/

Please visit to see the exciting Conference Program!

Abstract Submission

The deadline for paper submission has passed. However, if you missed previous notices and have a paper ready to submit, please communicate with Metin Yetisir (yetisirm@aecl.ca).

Whether or not you make a submission, make plans to attend the conference. You will find it of benefit!

Technical Meeting Organizers

Advisory Committee: Adriaan Buijs (McMaster University), Benjamin Rouben (12&1 Consulting), Bhaskar Sur (AECL), Brent Lewis (UOIT), Dan Brady (NRCAN), Eleodor Nichita (UOIT), John Root (Fedoruk Centre), John Goldak (Carleton University), John Katsaras (ORNL), Marcel de Vos (CNSC)

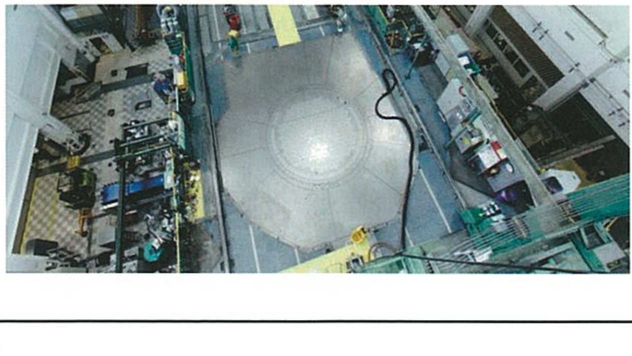
Honorary Chair .... Romney Duffey (DSM Associates)
General Chair .... Metin Yetisir, AECL
Technical Program Chair .... Steve Livingstone, AECL

Key Dates

Conference Dates .... 2014 Nov. 5- 6
Tours of Chalk River Laboratories (optional) ....2014 Nov. 7

Further Information

Additional information is available from www.cns-snc.ca/events/3tm/ or Metin Yetisir, General Chair, AECL, Tel: (613) 584-8811 ext. 46577; Email: yetisirm@aecl.ca.



Calendar

2014

Sept. 28-Oct. 3 — **Physor 2014**
Kyoto, Japan
For information: CNS office
cns-snc@on.aibn.com

Oct. 6-Oct. 7 — **CANDU Fuel Technology Course**
Best West Plus Durham Hotel
For information: CNS office
cns-snc@on.aibn.com

Oct. 26-Oct. 31 — **Nuclear Plant Chemistry Conference 2014 (NPC-2014)**
Sapporo, Japan
website: www.npc2014.net

Nov. 5-Nov. 7 — **3rd International Technical Meeting on Small Reactors**
Ottawa, Ontario, Canada
Ottawa Marriott Hotel
website: www.cns-snc.ca

Nov. 9-Nov. 13 — **American Nuclear Society - Winter Meeting**
Anaheim, California
website: www.ans.org

2015

Feb. 21-Feb. 26 — **9th International Conference on Nuclear Plant Instrumentation, Control & Human-Machine Interface Technologies (NPIC & HMIT 2015)**
Charlotte, NC
website: www.cns-snc.ca

Mar. 15-Mar. 18 — **7th International Symposium on Supercritical Water-Cooled Reactors (ISSCWR-7)**
Helsinki, Finland
website: www.cns-snc.ca

May 25-May 27 — **4th Climate Change Technology Conference (CCTC-2015)**
Hotel Omni, Mont-Royal
website: www.cns-snc.ca

May 31-June 3 — **CNS 2015 Annual Conference**
Saint John Hilton and Conference Centre
website: www.cns-snc.ca

June 17-June 19 — **1st International Technical Meeting on Fire Safety and Emergency Preparedness for the Nuclear Industry**
Delta Meadowvale Hotel and Conference Centre, Mississauga, ON
website: www.cns-snc.ca

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

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

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

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

New CANDU Textbook

The University Network for Excellence in Nuclear Engineering (UNENE) has announced that a new textbook for the design of CANDU reactors is now available.

Titled "The Essential CANDU" the new textbook was, developed jointly with the CANDU Owners Group.

The textbook explains the science and engineering of nuclear reactors, with emphasis on the CANDU design; and provides a unique and comprehensive learning resource for students, educators, trainers and working professionals. The material is suitable for the senior undergraduate or graduate level in university engineering and science.

The textbook also supplements and augments the course materials provided to students enrolled in the UNENE M.Eng. program.

The textbook is provided free of charge in pdf format at the following link www.nuceng.ca/candu. Copyright is retained by UNENE.

A Nucleus by Any Other Name

by JEREMY WHITLOCK

Why hello Nuclear Power. Imagine seeing you here, on the streets of Vancouver!

You must be mistaken...

Oh I don't think so! That self-conscious shuffle, that uncertain contenance, the pasty-white skin... your hood and sunglasses don't fool me for a second!

Uh, I couldn't be this Nuclear Power you're thinking of, sir, not in a Nuclear Free City like Vancouver...

You must be at the Pacific Basin Nuclear Conference over at the Hyatt – I think I saw the bylaw enforcement SWAT team massing on the curb this morning, ready to move in... hee hee

Sir, I am ... uh... Green Power... see, I'm even wearing these here sandals...

With socks! Black socks at that. Give it up Nuke. How's the conference going anyway?

Well yes.. the... er... conference on ... advanced specialized green energy technology is going quite well. About 600 attendees from around the world, lots of exhibitors, lots of discussion ... about green energy.

Derived from..?

The atom.

Be more specific!

Deep down inside... sub-electron... safe and green...

I see, not the...?

Yes, the nacelle.

Pardon me?

Well, if the atom were a wind turbine, then our energy would come from the nacelle.

Nacelle power?

Yes. Nacelle power. Safe and green. Look it up – nacelle.

And so, over at the PBNC there are 600 attendees from the... nacelle industry talking about the future of nacelle power, such as...?

Small Modular Nacelle units, Generation IV nacelle technology, nacelle aging management, nacelle fuel design, nacelle thermalhydraulics, nacelle physics ... all safe and green, yup.

And tell me, with Vancouver being a Nuclear Free City, does that mean that the PET scanners here use...?

Nacelle isotopes, yup. That's all they use in the Nacelle Medicine departments in the hospitals in Vancouver. Nacelle isotopes only emit good feelings as they course throughout a patient's body, and doctors totally zone in on those good feelings. And the really, really positive feelings come from TRIUMPH over at UBC – they have accelerators there that wind up nacelle energy really tight and shine it in all directions, to make everyone happy and able to do amazing things like generate electricity with absolutely zero risk, and drive oil tankers and other freight ships through Burrard Inlet which are completely green and safe, as long as the nuclear powered U.S. Navy ships stay anchored outside of city limits because they have the evil of Satan in them.

Um, are you okay...?

It's been a long week. And it's just that those float planes in the harbour keep coming and going and coming...

Well cheer up – your week's almost over and it seems your "Nacelle" conference has flown under the radar of the Anti-Nuke Police. And what's more, I understand B.C. is the fusion capital of Canada these days so it's not all doom and gloom on the "N" word here.

Ahem, it's not fusion, it's "solar 2.0".

Gotcha. Bringing the power of the sun down to earth.

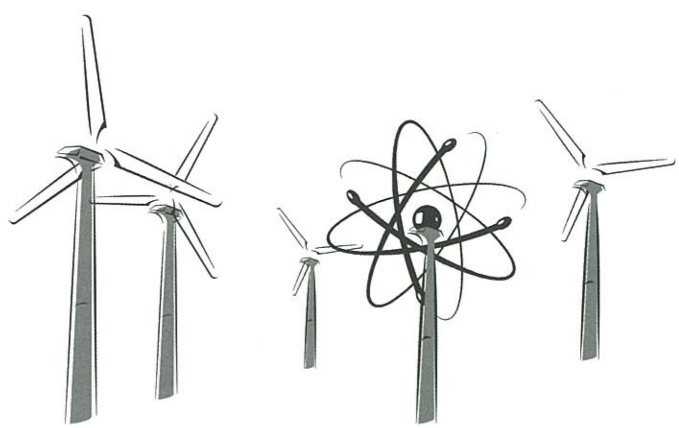
Safe and green.

And look, you shouldn't take this whole Nuclear Free thing personally. I mean, the province is practically 100% run on water power anyway – except for a wee little 1000 MW natural gas plant running Vancouver when the water's low.

Yikes, the irony makes my head hurt.

Well be off with you then, Mr. Green Energy of the Nacelle Industry. And don't forget to relax and partake in some of Vancouver's culture before you leave.

Safe and green all the way my friend.



2014-2015 CNS Council • *Conseil de la SNC*

Executive / *Exécutif*

President / *Président*	Jacques A. Plourde 905-441-2776
e-mail	jap-performance@rogers.com
Past President / *Président sortant*	Adriaan Buijs 905-525-9140 x24925
e-mail	buijsa@mcmaster.ca
1st Vice-President / *1ier Vice-Président*	Vacant
2nd Vice-President / *2ième Vice-Président*	Peter Ozemoyah 289-288-0490 x249
e-mail	pozemoyah@tyne-engineering.com
Treasurer / *Trésorier*	Mohamed Younis 416-592-6516
e-mail	mohamed.younis@amec.com
Secretary / *Secrétaire*	Colin G. Hunt 613-742-8476
e-mail	colin.hunt@rogers.com
Financial Administrator / *Administrateur financier*	Ken L. Smith 905-828-8216
e-mail	unecan@rogers.com
Executive Director / *Directeur exécutif*	Ben Rouben 416-663-3252
e-mail	roubenb@alum.mit.edu
Communications Director / *Directeur des communications*	Jeremy Whitlock 613-584-3311 x44265
e-mail	whitlockj@aecl.ca

Members-at-Large / *Membres sans portefeuille*

Parva Alavi 905-599-9534
Frederick C. Boyd 613-823-2272
Emily Corcoran .... 613-541-6000 x 6510
Rudy Cronk 905-949-2755
Ruxandra Dranga .... 613-584-3311 x 46856
Daniel Gammage .... 519-621-2130 x 2166
Mohinder Grover 416-499-5591
Kris K. Mohan 905-332-8067
Dorin Nichita 905-721-8668
Tracy Pearce .... 613-584-3311 x 44084
Jad Popovic 905-820-7472
John G. Roberts 519-361-5898
Ben Rouben 416-663-3252
Nick Sion 416-487-2740
Ken Smith 905-828-8216
Aman Usmani 416-217-2167
Jeremy Whitlock .... 613-584-3311 x 44265
Syed Zaidi 905-763-9860
Ex Officio: John Barrett, CNA ... 613-237-4262
barrettj@cna.ca

CNS Committees / *Comités de la SNC*

Program / Programme
Tracy Pearce .... 613-584-3311 x44084 pearcetl@aecl.ca

CNA Interface / Interface avec l'ANC
Alex Wolf .... 613-237-4262 x109 wolfa@cna.ca

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

Branch Affairs / Chapitres locaux
Syed Zaidi .... smh@zaidi.net

COG Interface / Interface avec COG
Frank W. Doyle .... 416-595-1888 x156 frank.doyle@candu.org

OCI Interface / Interface avec OCI
Peter Ozemoyah 289-288-0490 x249

Education and Communications / Éducation et communications
Ruxandra Dranga .... 613-584-3311 x46856 drangar@aecl.ca

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

Finance / Finances
Mohamed Younis .... 416-592-6516 mohamed.younis@amec.com

Bulletin
Fred Boyd .... 613-823-2273 fboyd@sympatico.co

Past Presidents / Anciens présidents
Adriaan Buijs .... 905-525-9140 x24925 buijs@mcmaster.ca

Honours and Awards / Prix et honneurs
Ruxandra Dranga .... 613-584-3311 x46856 drangar@aecl.ca

Internet / Internet
Adriaan Buijs .... 905-525-9140 x24925 adriaan.buijs@sympatico.ca

Inter-society Relations / Relations inter-sociétés
Peter Ozemoyah .... 289-288-0490 x249 pozemoyah@tyne-engineering.com

Young Generation / Jeune génération
Rahim Lakhani .... 519-832-8268 rahim.lakhni@amec.com

Scholarship / Bourses
Mohamed Younis .... 613-592-2256 mohamed.younis@amec.com
.... 416-592-6516

Technical Divisions / *Divisions techniques*

- Nuclear Science & Engineering / Science et génie nucléaires
  Elisabeth Varin 514-953-9790 varine@gmail.com
- Fuel Technologies / Technologies du combustible
  To 2014 October 7:
  Steve Palleck 705-652-7784 spalleck@bell.net
  From 2014 October 8:
  Paul Chan 613-541-6000 x6145 paul.chan@rmc.ca
- Design and Materials / Conception et matériaux
  Daniel Gammage 519-621-2130 x2166 dgammage@babcock.com
- Environment & Waste Management / Environnement et gestion des déchets
  Parva Alavi 905-599-9534 parvaalavi@gmail.com
- Nuclear Operations & Maintenance/ Exploitation nucléaire et entretien de centrale
  Jacques Plourde 905-441-2776 jap-performance@rogers.com
- Medical Applications and Radiation Protection/Applications médicales et protection contre les rayonnements
  Nick Sion 416-487-2740 sionn@sympatico.ca
- Fusion Science and Technology / Science et technologie de la fusion
  Blair Bromley 613-584-3311 x43676 bromleyb@aecl.ca

CNA Liaison / *Agent de liaison avec l'ANC*

John Barrett 613-237-4262 barrettj@cna.ca

CNS Bulletin Publisher / Éditeur du Bulletin SNC

Fred Boyd 613-823-2272 fboyd@sympatico.ca

CNS Bulletin Editor / Rédacteur du Bulletin SNC

Ric Fluke 416-592-4110 rfluke@sympatico.ca

CNS Office Manager / Bureau de la SNC

Denise Rouben 416-977-7620 denise.rouben@sympatico.ca
Bob O'Sullivan 416-977-7620 cns-snc@on.aibn.com

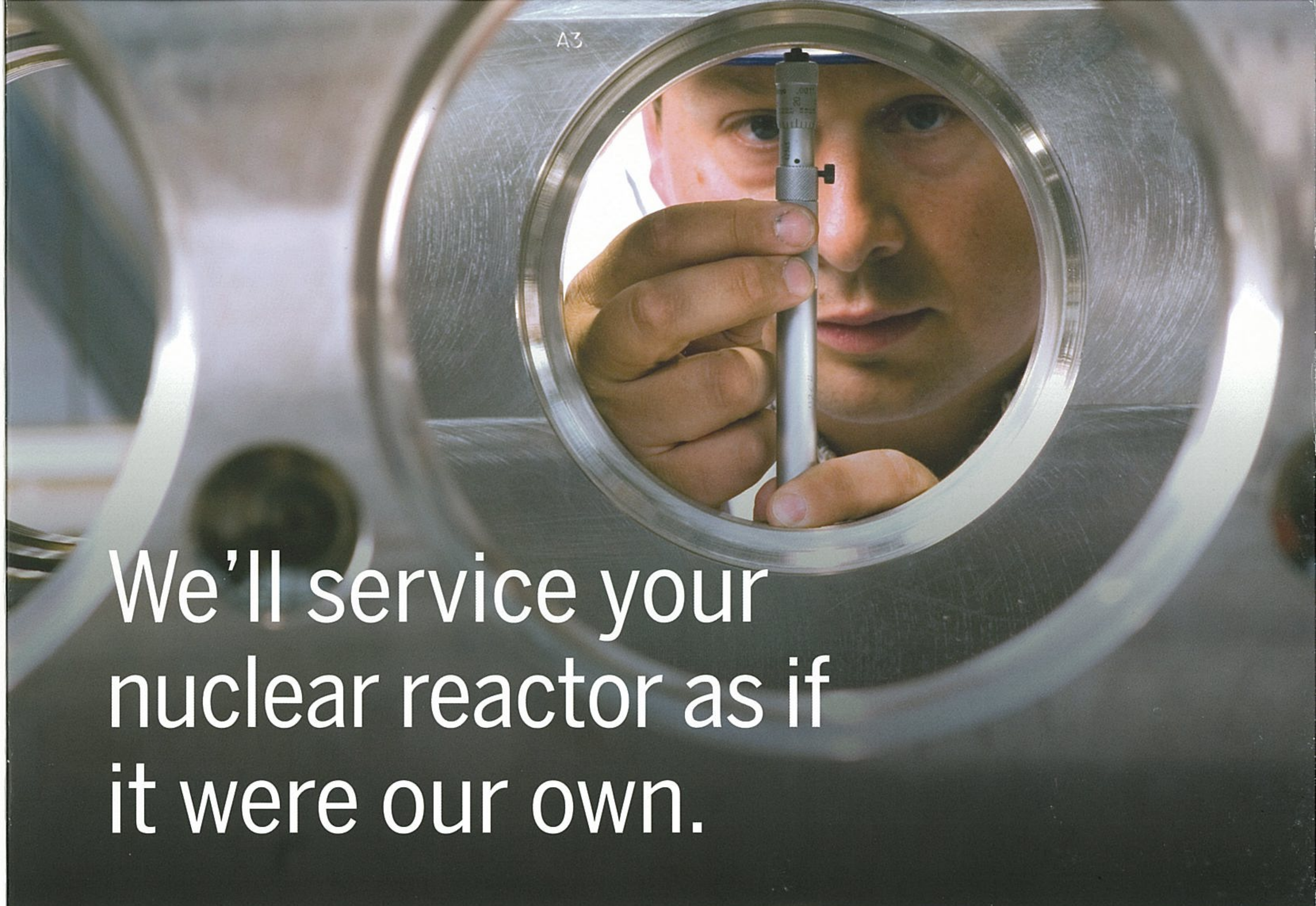
Branches / Chapitres locaux

Bruce	John Krane	519-361-4286 jck@bmts.com
Chalk River	Scott Read	613-584-3311 scott.ad.read@gmail.com
Darlington	Jacques Plourde	905-441-2776 jap-performance@rogers.com
Golden Horseshoe	David Girard	905-525-9140 girarddj@gmail.com
Manitoba	Jason Martino	204-753-2311 x62229 martinoj@aecl.ca
New Brunswick	Mark McIntyre	506-659-7636 mmcintyre@atlanticnuclear.ca
Ottawa	Ken Kirkhope	ken.kirkhope@cnsc-ccsn.gc.ca
Pickering	Leon Simeon	905-839-1151 x2520 leon.simeon@opg.ca
Québec	Michel Saint-Denis	514-875-3452 michelstdenis@videotron.qc.ca
Sheridan Park	Raj Jain	raj.jain@candu.com
Toronto	Andrew Ali	andrew.ali@amec.com
UOIT	Terry Price	terry.price@uoit.ca
Western	Jason Donev	403-210-6343 jmdonev@ucalgary.ca

CNS WEB Page - Site internet de la SNC

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

http://www.cns-snc.ca



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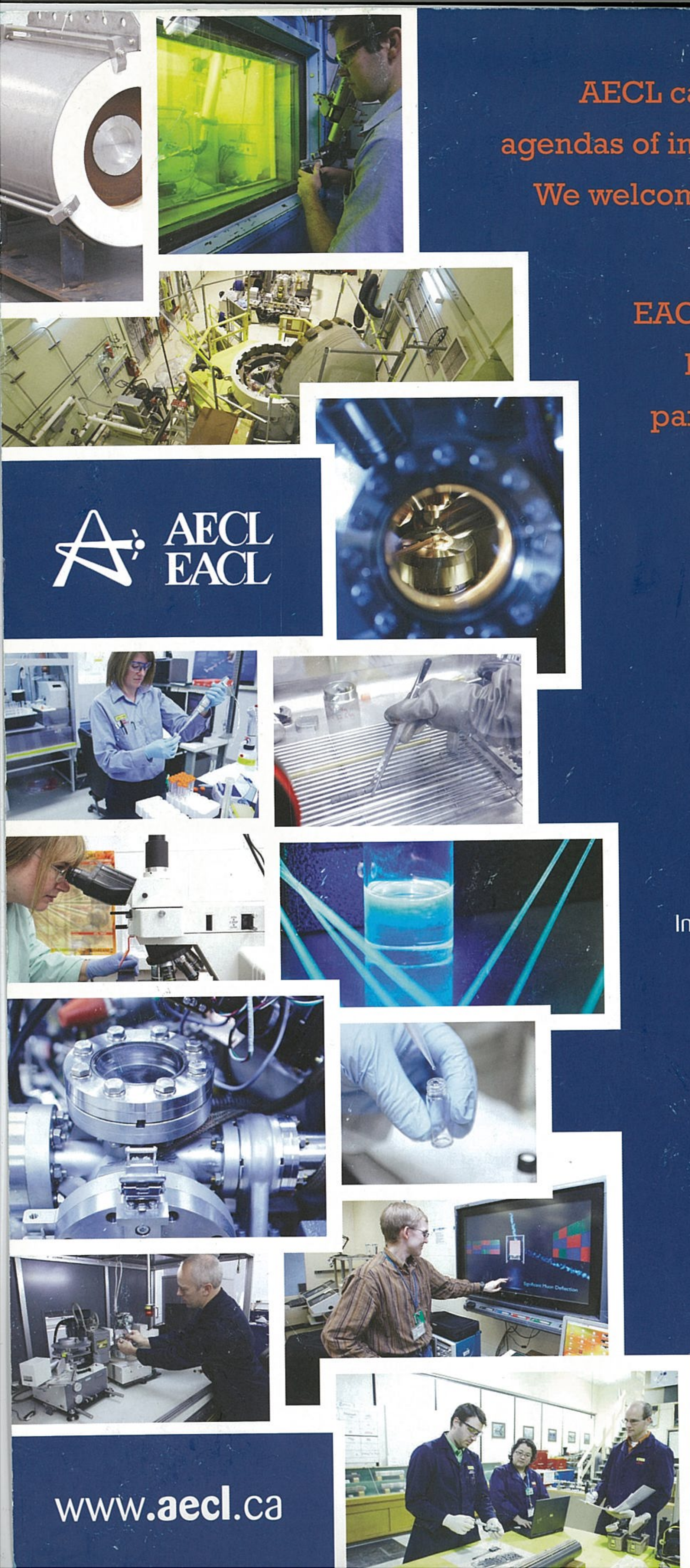

AECL can help advance the innovation agendas of industry and academic partners. We welcome opportunities to collaborate.

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Fission Products Behaviour Laboratory
Laboratoire de diffraction des rayons X
Confinement de substances réglementées
Fuel Development Branch
Installation de fissuration par hydruration retardée
Health Physics Neutron Generator
Installation de radiographie numérique
High Pressure Water Test Loop Facilities
L'irradiateur Gammacell 220 au cobalt 60
High Temperature Fuel Channel Laboratory
Simulation dynamique GEANT4
Large Scale Containment Facility
Laboratoires d'essais mécaniques
Laser Dimensioning
Laboratoire de développement de modèles
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