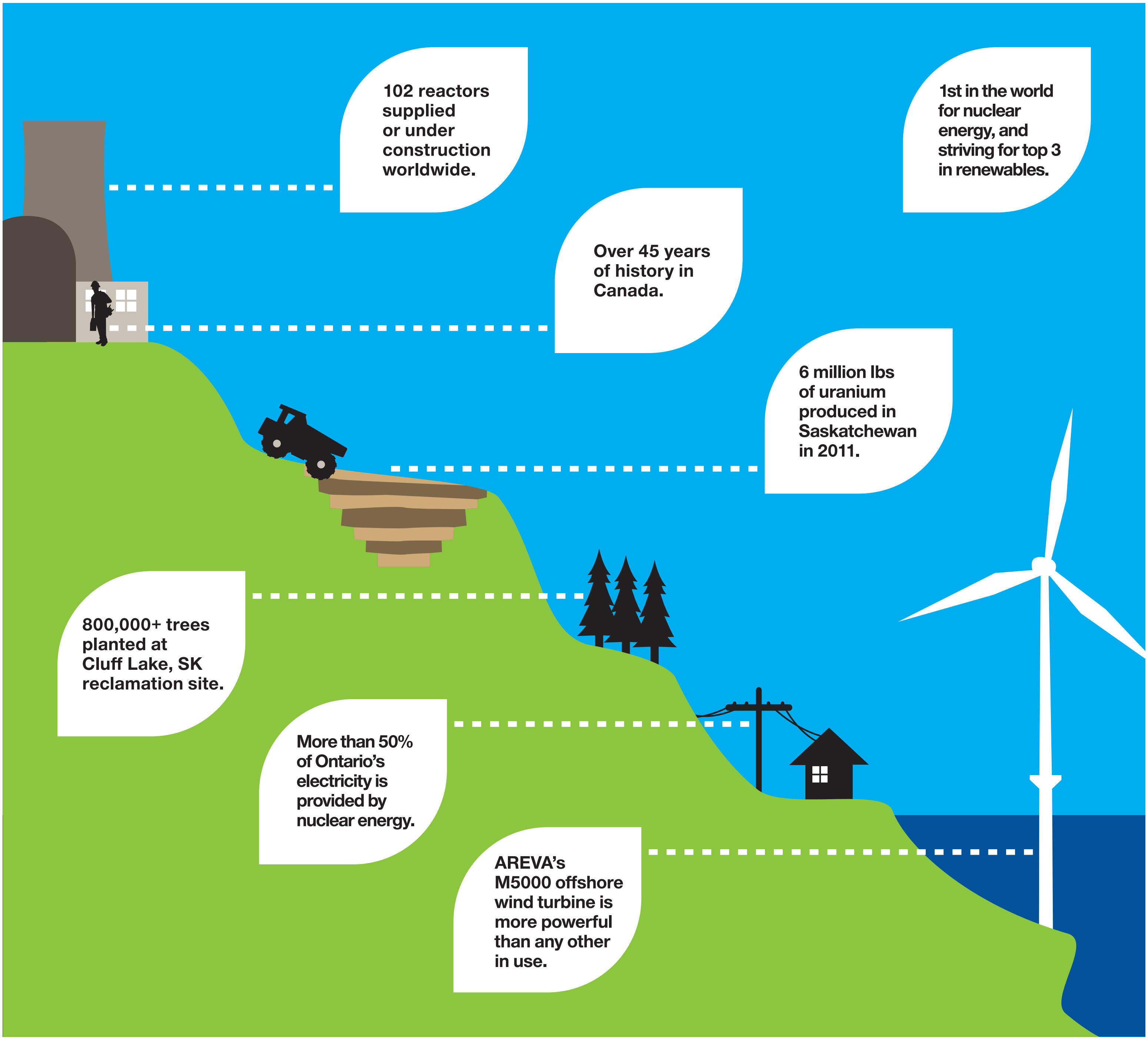
CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

JUNE 2012 JUIN VOL. 33, NO.2

- 33rd CNS Annual Conference
- Honours and Awards
- W.B. Lewis Lecture
- Paper - A CANDU-Type Small Reactor



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Small: The New Big

With Saskatoon, Saskatchewan being the venue of this year's Annual Conference of the Canadian Nuclear Society it was interesting and appropriate to include discussions on Small Modular Reactors. As noted by Robert Watson, President and CEO of SaskPower, the provincially owned electricity utility, Saskatchewan covers an immense area "with more transmission poles than people" for a grid that is only 4000 MWe, mostly from imported coal. However, Saskatchewan is rich in uranium and its economic growth is expected to double in less than a decade. It makes sense to meet the increasing demand for electricity using its home-grown resources. However, current reactor offerings are simply too big for a small and dispersed load on its grid. The solution that is environmentally and economically feasible, without creating grid stability problems, is the introduction of small reactors.

"Small" means between 40 and 200 MWe according to most vendors although the CNSC definition for licensing purposes is 200 MWt (thermal) which would be less than about 70 MWe (electric). The CANDU EC6 is a mid-sized reactor producing about 700 MWe. The paper by Dr. Meneley (in this issue) is suggesting a CANDU-type reactor at about 50 MWe intended for the far north where expensive diesel is currently in use.

Conventional sized reactor projects often run into financial problems because the markets do not want to assume the significant risk of a capital intensive project that may take ten years to complete, and when the electricity demand may be much less on completion than predicted when the project was approved. However, small reactors, which can be fabricated in modules at the factory and shipped practically in one piece to the site, are less expensive to build, and can be introduced on an as-needed basis to match the real growth in demand (as opposed to predicted growth). This makes the financial return much more predictable and reduces the risk to the capital markets. It also helps stabilize the grid by locating the reactors close to where the growth in demand is centred, compared to the less stable use of large reactors with very long transmission lines to the load centre.

There are commercial prospects for small reactors in the works. NuScale is developing a 40 MWe modular reactor while Babcock and Wilcox Canada, with its US partners, are developing a 180 MWe reactor. Westinghouse is also developing a small modular reactor that will produce 200 MWe, which is about the same output as the now decommissioned Douglas Point reactor at the Bruce site.

Although Ontario is anticipating new build at Darlington of the conventional reactor size, there are growing markets for small modular reactors in remote areas that now use diesel, and in places such as Saskatchewan where demand is growing but the size of the reactors is constrained, primarily by economic factors, by its relatively small electricity grid.

When it comes to new reactors, Small, it would seem, is the new Big!

In This Issue

This June edition (although it went to press in July) contains more material than usual primarily because it features reports from our **33rd Annual Conference**, our **Annual General Meeting** and the changing of the CNS Executive. We welcome our new president, **Dr. John Roberts**, and the new executive council is shown in the CNS section of this Bulletin. The full slate of the Council had not been determined at press time, so the Council Page usually found on the last page of the Bulletin has been removed, and will return, fully updated in the September edition.

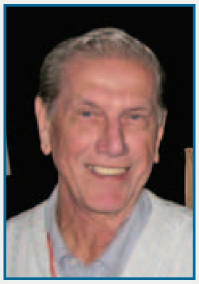
At this year's conference the traditional **W.B. Lewis Lecture** was presented by **Laurier L. Schramm**, President and CEO, Saskatchewan Research Council, on the remediation of abandoned uranium mines in northern Saskatchewan, and is printed in this edition. There was also a lot of interest in **Small Modular Reactors**, including **Dan Meneley's** technical paper on a CANDU-type small power reactor printed in this edition.

The cover photo shows the **Synchrotron Building** on the campus of the University of Saskatchewan, Saskatoon, where the Annual Conference was held. The Synchrotron, part of the **Canadian Light Source**, is one of four government funding initiatives for the production of **medical isotopes**, and is already showing promising results (see the technical paper on photo-neutron reactions in the Canadian Light Source).

We have also compiled a set of general news items, news from our Branches, and "**Meet the President**" with some interesting background on John Gryffydd Roberts and something about a "bilingual Pantomime". Also and always, the poetic works of **Jeremy Whitlock** are found in **Endpoint**, located at the end of this Bulletin (otherwise we couldn't call it "Endpoint") ...

Letters and comments are always welcome. Have a safe and enjoyable summer!

From The Publisher



The Society

The past three months have been busy ones for the Canadian Nuclear Society, highlighted by the 33rd Annual Conference, held, this year, in Saskatoon, Saskatchewan.

Thanks to an army of volunteers, overseen by John Roberts who was elevated to the position of President of the Society at the Annual General Meeting held in Saskatoon immediately before the opening of the Annual Conference, the conference was very successful. It was particularly gratifying to have the strong involvement of Saskatchewan agencies, especially SaskPower which was the primary sponsor and the City of Saskatoon, also a sponsor. In addition, the Saskatchewan Research Council and the recently formed Canadian Centre for Nuclear Research were exhibitors.

Another positive aspect of the conference was the presence of well over 70 student members. They added vitality to the gathering and, in the quality of their presentations in the poster competition, displayed great intelligence and scholarship. Their presence was assisted by generous grants from SaskPower and Ontario Power Generation

The Annual General Meeting was the typical perfunctory session with about 35 members present. There was no debate, no new motions, and the proposed slate of Council members was voted in on acclamation as has been common for several years. Subsequently, a question arose about a further candidate, which would have meant the requirement for an election. On review this matter was clarified and the acclaimed Council affirmed. (Members are listed in the CNS News section.)

For some years the governance of the Society has been determined by the small number of members who manage to attend the AGM. With well over 1,000 members it is my belief that wider participation is desirable. Other organizations have gone to electronic methods for both nominations and voting. Perhaps the CNS could move in that direction.

A pressing issue for the new Council is the need to revise the Constitution and By Laws to fit the requirements of the new Canadian Not-for-profit Corporation Act (CNCA). This has to be done and ratified by a General Meeting by the fall of next year. The new Council has already established a committee which is working on the task.

This fall has turned out to be a busy time for the Society with three conferences on the calendar. And, if you add in the **Nuclear Education and Outreach Workshop**, the program begins in August. The three conferences are all advertised in the CNS News section, but to save you jumping to the back of the issue they are: **Simulation Symposium**, in Ottawa, October 14 -16; **Small Reactor Meeting**, also in Ottawa, November 7 – 9; and the large one focussing on many aspects of power reactors, called, **Steam Generators to Controls Conference**, in Toronto, November 11 -14.

As you will note in the General News section, Atomic Energy of Canada Limited – Nuclear Laboratories (AECL-NL) has created an electronic journal. From a small sample of CNS members this has been met with a mixed reaction. It appears that there is no other example of a commercial organization publishing a peer-reviewed scientific journal. In any event its existence has caused the Society to reconsider its approval, in principle, of the creation of a Canadian nuclear journal, again in electronic format. Although it has been under consideration for more than a year, the CNS journal has not yet been launched. Now that the AECL-NL sponsored one has been launched, the Society is faced with the question of whether or not to go ahead with its journal.

Canadian Nuclear Program

There is little to say about the nuclear power program in Canada. The refurbishments at both Bruce and Point Lepreau are still in the final stretch. In the case of Bruce it must be disappointing, to say the least, to have the restart of Unit 2 delayed at the last moment by a non-nuclear problem.

On a positive note Ontario Power Generation has issued contracts for preparation of new units at Darlington so that they will be ready to go once (or if) the provincial government makes up its mind. If the government does not soon decide, a real power crunch will occur in 2020 when Pickering is scheduled to shut down. There is no likelihood that the Premier's pets of wind and solar will be able to replace the Pickering generation.

On the international scene it is interesting that the Japanese government has finally issued a report admitting to the organizational and cultural factors that were the underlying cause of the nuclear failures at Fukushima in March 2011. In particular the weakness of the regulatory system has been acknowledged. The strict independence, openness and competence of our Canadian Nuclear Safety commission stand out in sharp contrast.

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~ Cover Photo ~

Aerial view of the Synchrotron building with the University of Saskatchewan campus and the City of Saskatoon in the background.

Photo courtesy of Canadian Light Source Inc.

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bulletin

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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.

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2012 CNS Annual Conference

Successful meeting in Saskatoon

by FRED BOYD

This year the Canadian Nuclear Society moved west for its *33rd Annual Conference*, to Saskatoon, Saskatchewan. The distance from the majority of nuclear activities located in eastern Canada did not deter the more than 360 delegates who attended the event held June 10-13, 2012. This includes the three score of students participating in the embedded *36th Student Conference* sponsored jointly by the CNS and the Canadian Nuclear Association.

The venue had been chosen over two years ago at the invitation of Saskatchewan premier, Brad Wall. At that time the Saskatchewan government was exploring the possibility of introducing nuclear power to the province. Although that initiative was terminated, the province is still a major producer of uranium and has an active nuclear research program which includes the Canadian Light Source (a large synchrotron) and a Slowpoke reactor. The province is also exploring the use of accelerators for the production of radioisotopes for medical purposes and has created a Centre for Nuclear Innovation.

With a theme of *Building on the Past – Building for the Future* the conference specifically noted the 50th anniversary of the first nuclear-produced electricity in Canada by the small Nuclear Power Demonstration (NPD) plant on June 4, 1962 and the 60th anniversary of the creation of Atomic Energy of Canada Limited in April 1952.

Prior to the official opening of the conference on the Sunday evening there was an all-day Professional Development Seminar organized by the North American – Young Generation Nuclear (NA-YGN) association. The Annual General Meeting of the CNS also took place that afternoon. *(See a separate report on the CNS-AGM in the CNS section of this issue.)*

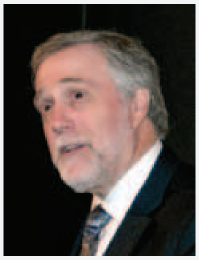
At the opening reception held on the Sunday evening, CNS President, **Frank Doyle**, welcomed delegates and introduced the mayor of Saskatoon, **Donald Atchison**, who spoke enthusiastically about his attractive city.

Frank Doyle officially opened the conference on the Monday morning and noted the special session to be held the next day on NPD. He then invited **Ron Oberth**, president of the Organization of CANDU Industries, to chair the opening plenary session on the theme, *Building Stakeholder Support: Nuclear in Western Canada.*

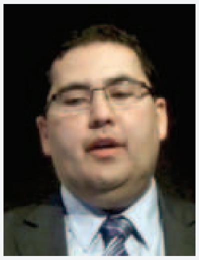
Leading off was **Robert Watson**, President and CEO of SaskPower, the provincially owned electricity utility. He began by noting the province's resources: uranium in the north; potash in the southwest and oil in the southeast. The province is in its 15th year of economic growth, he stated, with the lowest unemployment in the country.

As well as developing natural resources, the province is encouraging innovation, he said, and mentioned the Canadian Light Source synchrotron, the Saskatchewan Research Council and the new Centre for Nuclear Innovation.

SaskPower, he noted, is a relatively small utility with a total generation capacity of about 4,000 megawatts. Much of that generation is by coal. The customers are very dispersed, resulting in an extended network. "There are more transmission poles than people", he quipped. Industrial demand is expected to double in less than a decade, with much of the growth in mining. He predicted that they would be looking at small nuclear plants by 2030.



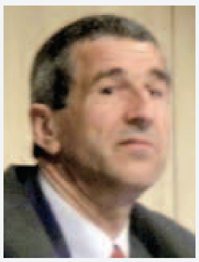
The next speaker was **Robert Walker**, President and CEO of AECL-NL, who focussed on *"Stakeholder Opportunities through Nuclear Science and Technology".* He noted that Canada is one of a small number of countries with a comprehensive nuclear sector that includes: a strong central regulatory structure; a good supply chain; high quality education regime; and, he added, AECL Nuclear Laboratories. While the nuclear sector has strategic advantages, he said, there are continuing public misperceptions.



Gary Merasty, Vice-President, Corporate Social Responsibility, Cameco Corporation, was the third speaker of the opening trilogy. He spoke about the particular social challenges of working in northern Saskatchewan with a population, mostly first nations, of just 40,000, scattered in more than 40 communities. He mentioned that Cameco's approach was more "Hands Up" rather than "Hand Outs". There is a strong entrepreneurial spirit among the first nation people, he said, but also a political culture of grievance. Cameco's target, with the assistance of the province, is to employ two thirds first nations personnel.

After a break, the opening plenary session continued under the chairmanship of **Christopher Deir**, Manager, Nuclear Business Development, Babcock & Wilcox Canada Ltd.

John Root, Interim Director, Canadian Centre for Nuclear Innovation, which is associated with the University of Saskatchewan, began by outlining the targets for the newly announced Centre. These are: advancing nuclear medicine; advancing knowledge of materials; improving safety; managing environmental and security issues. It will report to the Board of the U of S. At this early stage of the organization he said the focus is on: selection of personnel; identifying a permanent leader; identifying potential partners; securing funding.



A uranium mining perspective was provided by **Vincent Martin**, President and CEO, AREVA Canada Inc. He summarized world and Canadian uranium production, noting that Canada's (Saskatchewan's) percentage had fallen because of the large increase of production in Kazakhstan. Worldwide production is just 85per cent of demand, the balance being supplied by the demilitarization program. McArthur River mine in Saskatchewan is still the largest in the world and he termed Cigar Lake the next "big one" now that the flooding problems are largely solved.

Rounding out the opening plenary was **Kevin Wallace**, President and General Manager, Candu Energy Inc. He began with reference to the Fukushima event of March 2011 and a brief overview of the broad energy scene. Regarding his new company, he noted its role within SNC Lavalin Global and commented it is still in the restructuring phrase since SNC Lavalin's purchase of AECL's engineering group. Candu Energy's focus will be on several phases, including: new build; services; and maintenance. In closing he commented that for "new build" a domestic project would be a springboard for international growth.

At the luncheon, **Dr. Laurier Schramm**, President and CEO of the Saskatchewan Research Council, gave the invited W. B. Lewis lecture. These lectures are sponsored by AECL in memory of Dr. W. Bennett Lewis, who directed the research program at the Chalk River Laboratory from 1946 – 1952 under the National Research Council and from 1952 – 1973 as Vice-President Research, Atomic Energy of Canada Limited.

Schramm spoke about early (1950s) uranium mining in Saskatchewan which was primarily centred around Uranium City, the town established in 1952 to service the Beaverlodge and other mines in the area. The closure of the mines in 1983 led to economic collapse and left considerable contamination. In 2005, the Saskatchewan Research Council was assigned the task of cleaning up the area. *(The text of Schramm's lecture is included in this issue of the CNS Bulletin.)*

The afternoon of Monday, morning of Tuesday and afternoon of Wednesday were devoted to technical sessions, typically six to seven sessions in parallel. The subject matter was very broad, as indicated by the session titles:

- Physics
- Environment and Waste Management
- Safety and Licensing
- Life extension
- Fusion technology
- Fuel and Advanced Reactors
- Reactor materials
- Uranium Mining
- I & C Process
- Thermalhydraulics

A further sub-set of papers were given in three sessions under the title of Western Focus Seminar.

Monday evening was a "fun" night at the Western Development Museum whose displays focus on the early development of the area in the late 1800s and early 1900s when thousands from Europe immigrated to the region.

The annual presentation of **Honours and Awards** took place following the Tuesday luncheon, *(See the separate report on the Honours and Awards in this issue of the Bulletin.)*

Following the Awards ceremony, there was a keynote address by **Michael Binder**, President and CEO, Canadian Nuclear Safety Commission. He reviewed the lessons learned from the Fukushima incident, the Government of Canada's *Responsible Resource Development* initiative, and provided an overview of the entire nuclear sector from the perspective of the regulator. *(Binder's slides are available on the CNSC website.)*

Two plenary sessions filled the balance of the Tuesday afternoon, beginning with one on *Small Modular Reactors*, chaired by Robert Walker of AECL-NL.

The first speaker was **Dan Ingersoll**, Director of Research Collaboration at NuScale Power, a US company pursuing a new design for small reactors. The company evolved in 2007 after the US Department of Energy terminated a joint program of the Idaho National Environmental & Engineering Laboratory and Organ State University on the development of a small LWR using natural circulation. The company is in the pre-application review phase with the US Nuclear Regulatory Commission. NuScale is designing both single-unit systems that will generate 40 Mw of electricity as well as multi-module facilities.

Next was **Chris Deir**, Nuclear Business Development Manager, Babcock & Wilcox Canada. B & W Canada is working with its US parent on the development of the B&W mPower reactor, a modular design of 180 MWe. This size has been chosen to match the load growth projections of many of the company's utility customers. The B&W mPower reactor features a four-year operating cycle without refueling, and is designed to produce clean, zero-emission operations.

Rounding out this session was **Ryan Blinn**, Technical Development Manager, Small Modular Reactor Program, Westinghouse Electric Company.

He described the Westinghouse Small Modular Reactor (SMR) as a 200 MWe class, integral pressurized water reactor, with all the primary components located inside the reactor vessel. It utilizes passive safety systems and proven components – as developed for the much larger AP1000 reactor design which is being built in China.

The second plenary session focussed on radioisotopes primarily for medical applications. It was chaired by **Bill Kupferschmidt**, Vice-President, Research and Development, AECL-NL

Leading off with an overview titled, *History of Nuclear Medicine: the Importance to Canadians*, was **Dr. Al Driedger**, Professor Emeritus, Radiology & Nuclear Medicine, University of Western Ontario.

He began by noting an 1898 paper by Marie Curie that described "a strongly radioactive substance" contained in pitchblende which was subsequently identified as radium. Radium soon became very popular for treating cancers and tumours, but was very expensive. Nevertheless, Saskatchewan pioneered its use and, in 1931, created the Saskatchewan Cancer Commission with clinics in Regina and Saskatoon. In the early 1950s, the radioisotope Cobalt 60 became available from the NRX reactor at Chalk River. Harold Johns, at the University of Saskatchewan and Ivan Smith of the London, Ontario Cancer Clinic, began treatments with teletherapy machines. He also mentioned the early successful use of Co 60 for the sterilization of Tse Tse flies in Zanzibar.

For the future he mentioned molecular imagining and the Human Genome Project. In closing he predicted that there would soon be personalized diagnostic imaging and therapy.

Karen Huynh, of Natural Resources Canada, provided an update on the federal government's programs to support alternative production methods for Technetium-99m, the most commonly used isotope for radioactive diagnosis. (Currently Tc 99m comes as a daughter of molybdenum-99 produced in reactors such as NRU.). The problems with NRU in 2007 and 2009 highlighted the fragility of the supply chain, she said.

In 2010 the federal government committed $48 million for a program called Isotope Supply Initiative of which $35 million was for proposals of non-reactor based production. The remaining $13 million was allotted to clinical trials and a study of the optimal use of medical isotopes. Four agreements were signed for production methods, to: Canadian Light Source; Prairie Isotope Production Enterprise; Advance Cyclotron Systems; and TRIUMF.

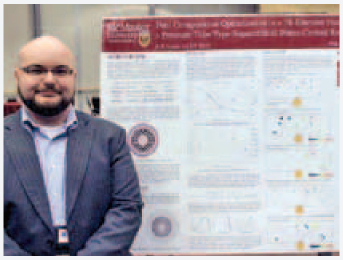
Work to date shows commercial production rates are feasible and efficient separation of Tc-99m has been developed. However, there are still questions about marketing. The current federal budget provides $17 million to continue the program.

(The text of the two remaining presentations by Richard Wier of Nordion and Kevita Murthy of CNSC were not available at the time of publication.)

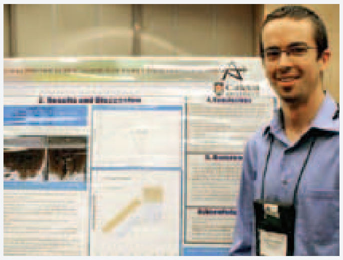
Student Conference

At the close of the Tuesday Plenary session, the 60 or so students set up their posters for the student conference competition. This was combined with a wine and cheese reception which resulted in considerable "traffic" and much discussion with the student presenters. Viewers were requested to ask questions and then fill out an evaluation form for submission to the judges.

The eventual winners were:



PhD – **David Hummel** (McMaster) - "Fuel Composition Optimization in a 78-Element Fuel Bundle for use in a Pressure Tube Type Supercritical Water-Cooled Reactor"



M.Sc – **Sean Hanlon** (Carleton) - "The effect of testing direction on DHC growth rate using a Zr-2.5Nb plate"

UG – **Michael Roeterink** (RMC) - "Optimization of Radio-Opaque Personal Protective Fabric by Monte Carlo Simulation"

The student awards were presented following the Wednesday lunch.

Three condensed plenary sessions were held on the Wednesday morning.

The first, entitled *Nuclear Industry Power Developments: The Renaissance*, was chaired by **John Roots**, Interim Director, Canadian Centre for Nuclear Innovation.

Ron Oberth, President, Organization of CANDU Industries, began with a presentation on the concept of "clusters" of related organizations entitled: *Nuclear Cluster Concept – Carolina / Ontario*. This can include industries with related interests; utilities; centres of higher education and other related organizations. He noted that Ontario has such a cluster, mentioning Candu Energy as a designer; the utilities Bruce Power and Ontario Power Generation; suppliers such as B&W Canada; General Electric Hitachi; Cameco, Rolls-Royce and others. He noted the UNENE program which enables professions to improve their qualifications through part-time university study.

An international perspective was offered by **Jarret Adams** of Areva, who noted that his company is involved in mining, engineering, construction, fuel production and more. It currently is involved in one form or other with 360 reactors around the world, in areas such as performance enhancement; upgrades; fuel supply; used fuel management. Areva currently has four nuclear power plants under construction; one each in Finland and France and two in China.

Michael Godfrey of Westinghouse began with a short history of his company's involvement with nuclear power, beginning with the nuclear-powered submarine, USS Nautilus, in 1954. That led to the first commercial nuclear plant in the USA, Shippingport, in 1957. The company is now solely focussed on commercial technology, he noted.

He then moved to talk about their AP 1000 design, emphasizing its passive safety features, modular design and reduced cost. The AP 1000 will dominate China's imports of nuclear plants, he commented in closing.

The final speaker of the session was **Jay Brister**, of the consulting company CH2M Hill, who dealt with the challenges new countries face in establishing a nuclear program. He referenced the milestones established by the International Atomic Energy Agency and noted the importance of non-technical issues such as training, financing, developing an infrastructure and others.

The second plenary session was in the form of a panel discussion, chaired by **Celeste Pendlebury**, Marketing Manager, Cameco Fuel Manufacturing.

Members of the panel were: **Mark Arnone**, VP, Refurbishment Implementation, Ontario Power Generation; **Rod Eagles**, Deputy Chief Nuclear Officer and Refurbishment Project Director, NB Power; and **Bill Pilkington**, Senior VP Products and Services, Candu Energy Inc.

Mark Arnone began with an overview of the proposed refurbishment of the Darlington four-unit station. They are currently in the planning phase. The first shutdown will be in 2016 and the refurbishment is scheduled to be completed in 2020. The reactors and the steam generators will be retubed, the turbine-generator overhauled and the entire station will be reviewed. He commented that the two inspection outages of the Vacuum Buildings, at Pickering and Darlington, provided good experience for organizing the many complex activities of the upcoming refurbishment.

A long list of items has been completed at Point Lepreau over the past year as the station is coming close to restart, Rod Eagles stated. At the time of the conference, he noted that a reactor building leak test is underway and new fuel is being loaded. On the way to restart the CNSC has set three regulatory "hold points": leaving the guaranteed shutdown state; at 15 % full power and at 35% full power.

Bill Pilkington referred to Candu Energy's involvement in seven projects as part of the life-extension exercise underway at the Embalse unit in Argentina, which will include upgrades. He noted that a number of the tools developed for the Point Lepreau refurbishment will be employed. He commented that Embalse had an 84% life-time capacity factor since 1984.

The closing plenary session focussed on the two significant anniversaries occurring in 2012: the 50th anniversary of the start-up of the Nuclear Power Demonstration (NPD) unit and the 60th anniversary of the creation of Atomic Energy of Canada Limited.

Lorne McConnell, the first station manager of NPD who went on to be Vice-President of the Ontario Hydro nuclear program and subsequently Senior Vice-President of all OH generation, provided an overall view of the early nuclear power program.

He began with a succinct review of the beginning of a nuclear program in Canada with the Montreal Laboratory in 1942, the conceptual design of the NRX research reactor, the establishment of the Chalk River Laboratories and building of NRX and subsequently NRU.

Beginning in 1953, studies were done on the possibility of using nuclear for electricity production. After quick approval by senior AECL and federal government officials, studies were conducted with the first proposal, essentially a pressurized version of NRU, to be called the Nuclear Power Demonstration (NPD). When it was realized that a commercial sized plant would require an excessively large pressure vessel and information became available about Zircaloy alloys the decision was made to switch to a pressure tube design, initially called NPD – 2. That redesign introduced the major concepts of the current CANDU.

Ontario Hydro went on to build 20 power reactors. A training centre attached to NPD provided the hundreds of qualified operators for these plants.

Jeremy Whitlock, a former president of the CNS and active communicator on nuclear matters, provided an interesting history of the origins the Canadian nuclear program, beginning with the Montreal Laboratory in 1942. That led to the building of the Chalk River Laboratories in 1944 and the creation of Atomic Energy of Canada Limited in 1952. He outlined many of AECL's accomplishments over the years.

The conference closed with a final set of technical sessions on the Wednesday afternoon.

That evening about 50 delegates took advantage of a tour of the large cyclotron at the Canadian Light Source and the small SLOWPOKE reactor at the Saskatchewan Research Centre, both located on the campus of the University of Saskatchewan.

The conference was organized and executed by a large group of volunteers chaired by John Roberts, now CNS President. Some of the key members were: Ben Rouben, general arrangements; Ken Smith, treasurer; the Plenary committee of Doug Burton, Mike Balfour, Dan Brady, Frank Dole, John McKenzie, and Ron Oberth; the technical committee co-chairs Wei Shen and Ki-Seob Sim; the student program co-chairs Emily Corcoran and Cherie Ferari; the Western Focus Session organized by Len Simpson and Duane Pendergast; the NA-YGN program organized by Natalie Sachar; the important sponsorship committee of Eric Williams, Anne Greve, and Frank Doyle; Honours and Awards, Krish Krishnan; publicity Jeremy Whitlock, and Denise Rouben and Bob O'Sullivan of the CNS staff who handled registration.

Host sponsor of the conference was SaskPower. A large number of other organizations provided sponsorship and most presented interesting exhibits. These were: AECL; Candu Energy; AMEC; AREVA; B & W Canada; B lack & McDonald; Bruce Power; Cameco; CNA; CNS; CNSC; Canmet Materials; City of Saskatoon; Energy Solutions; E. S. Fox; GE Hiachi; Genivar; Golder Associates; Hitachi; Kinectrics; OPG; Power Workers' Union; SNC-Lavalin Nuclear; Stern Laboratories; UOIT' Westinghouse. Other exhibitors included: Canberra; Canadian Centre for Nuclear Innovation; Canberra; Consolidated Controls; EcoMetrix; MarShield; Nucler Logisitics Inc; NuScale Power; Organization of CANDU Industries; Saskatchewan Research Council; UNENE; WiN.

The 2013 CNS Annual Conference will be held at the Hyatt Eaton Centre Hotel in Toronto, June.

Professional photographs were provided by Ron Heinrichs.

A CD with all of the technical papers and most of the Power Point presentations from the plenary sessions will be sent to all conference delegates and available for purchase from the CNS office.

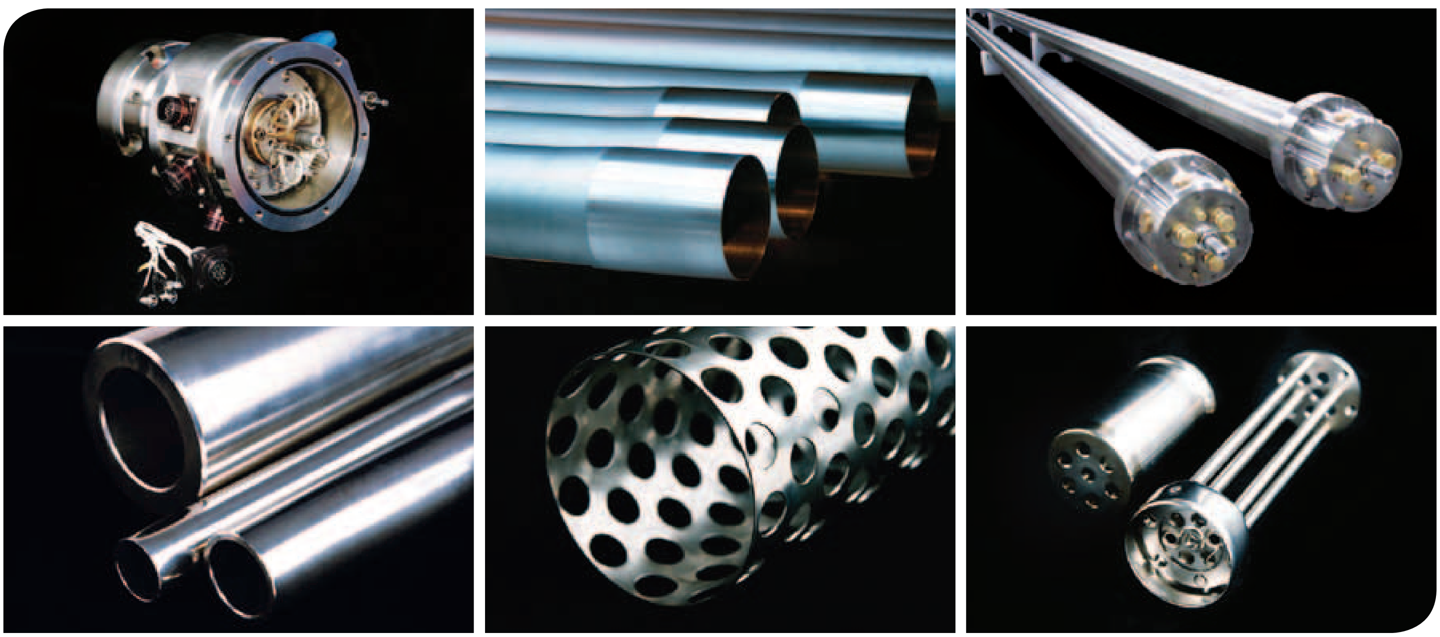
Scenes from the Conference

Technical Precision

Zr
Zirconium

Cameco Fuel Manufacturing (CFM) is a leading supplier of Reactor Components, Tubing, and Fuel Bundle Assemblies for the Candu PHWR. Having more than 50 years of experience with related nuclear technology, CFM specializes in cold working, fabricating, welding, brazing and machining of zirconium and its alloys, in addition to other specialty metals utilized in the global nuclear industry.

Our rigorous commitment to high quality nuclear standards combined with our extensive experience and unique capabilities makes Cameco Fuel Manufacturing a Supplier of Choice in the global nuclear industry.



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Canadian Nuclear Achievement Awards

Each year the Canadian Nuclear Society and the Canadian Nuclear Association join in awarding individuals and groups for significant contributions to the Canadian nuclear program. For the past several years these awards have been presented during the CNS Annual Conference.

For 2012 an exception was made in the case of the *Ian McRae Award*, which is given to an individual who has made substantive contributions, other than scientific, to the advancement of nuclear energy in Canada. That award was presented to Jerry Grandey, retiring CEO of Cameco Corporation, during the 2012 CNA Annual Conference and Trade Show in February 2012 and reported in the March 2012 issue (Vol. 33, No. 1) of the *CNS Bulletin*.

All the remaining 2012 awards were presented at the 33rd CNS Annual Conference, in Saskatoon, Saskatchewan, June 12, 2012. Following is a report on those awards.

Outstanding Contribution Award

The *Outstanding Contribution Award* recognizes 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. Contributions towards improved public safety are specifically included. Two Awards were presented: to Bill Kupferschmidt and Al Manzer.

Bill Kupferschmidt

Citation

Over his 30-year career at AECL, Dr. Bill Kupferschmidt has made outstanding contributions to the furthering of Canadian nuclear technology. Early in his career at AECL, Bill played a key role in the development of AECL's world-leading Iodine Chemistry Program. He was part of a team of AECL chemists that developed a comprehensive understanding of iodine behaviour during severe accident conditions. He was the lead in developing the Radioiodine Test Facility and its experimental programs. Later, as the Director of the Reactor Safety Division, he oversaw the relocation of this key research program from Whiteshell, and reestablishment at Chalk River with no interruption to the provision of R&D services to CANDU utilities.

Appointed in 2002 as General Manager of the Decommissioning and Waste Management Program, he was instrumental in developing the Nuclear Legacy Liabilities Program that was announced by the Government of Canada in 2005. In his current role as VP and GM of R&D at AECL, he is responsible for the full range of R&D programs that deliver on AECL's role as a federal nuclear science and technology organization.

With this award, Dr. Kupferschmidt is being recognized for the leadership he has provided to AECL's research programs in support of the Canadian nuclear industry throughout his career.

Al Manzer

Citation

Al Manzer's successful career has spanned nearly four decades entirely in nuclear fuel technology.

At the time of retirement from AECL in 2004, he was AECL's Principal Engineer for fuel design. He has been energetic and enthusiastic about CANDU fuel, and has made significant contributions in the areas of CANDU fuel design, testing, and fuel performance. In the late 1980s, Al applied an expert system to assessing and discovering defects in CANDU-6 fuel. In 2007, he was a central contributor to a fuel-defect investigation team at a major utility.

Al continues to be involved in all new CANDU fuel designs, such as ACR fuel, Thorium Fuel, Low Void Reactivity Fuel, Long Bundle, and the Modified 37 Element Fuel Bundle.

Al has the mutual respect of his colleagues across the industry and maintains that network. Most of these organizations have sought him out for assistance with fuel design, testing, or performance issues throughout his career and even in "retirement". He has mentored many new staff, prepared and delivered numerous fuel-related courses to industry staff and university students.

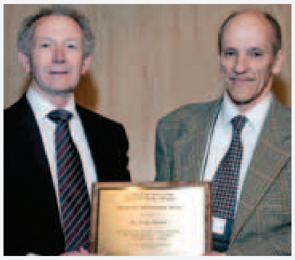
With this award, Al Manzer is being recognized for his extensive contributions to CANDU fuel design, testing and performance.

Innovative Achievement Award

Recipients of the *Innovative Achievement Award* are specially recognized for significant innovative achievement or the implementation of new concepts which display clear qualities of creativity, ingenuity and/or elegance and embody an impressive accomplishment in the nuclear field in Canada.

Greg Naterer

Citation



Greg Naterer, Professor and Associate Dean of the Faculty of Engineering and Applied Science at UOIT, is leading a 30-member, 5-country, 8-university international consortium on the development of the world's first copper-chlorine (Cu-Cl) cycle for nuclear hydrogen co-generation. The work has positioned Canada as a leader in the Cu-Cl cycle on the world stage at the Generation IV International Forum (GIF) Initiative.

This cycle has been shown to achieve higher efficiencies, lower environmental impact and lower costs of hydrogen production than other existing commercial technologies. It will be coupled with the AECL Supercritical-Water-Cooled (SCW) CANDU-reactor concept as the Canadian contribution to the Generation IV nuclear-reactor technology. This reactor will achieve 45-50% thermal efficiency compared to 30-35% for current designs. Also, with hydrogen co-generation through the copper-chlorine cycle, this reactor will be a top contender among all Generation IV reactors-based NPPs.

Due to the innovative research in nuclear engineering of Greg Naterer's team, other countries such as the UK, Romania, Argentina, India, China and South Africa, have also started their own programs on the Cu-Cl cycle. Because of his achievements in the development of nuclear-based co-generation of hydrogen, Greg Naterer was elected as a Chair of the Nuclear Hydrogen Division of the International Association of Hydrogen Energy (IAHE).

Education and Communication Award

The *Education and Communication Award* recognizes significant efforts in improving the understanding of nuclear science and technology among educators, students and the public. Three awards were presented this year, to: John Campbell; Cheryl Cottrill and the *Students On the Beam* program at the Canadian Light Source.

John Campbell

Citation

Prof. John Campbell was already a prolific communicator of Lord Rutherford's legacy when he assumed the ambitious task of assembling a three-hour documentary of the Scientist Supreme's life and accomplishments. Completed in 2010, the Rutherford documentary is a high-quality production, enabled only through Prof. Campbell's extensive efforts to raise funds, supply content, arrange interviews, and provide overall project management (including travel between New Zealand, Canada and the U.K., as well as dealing with the aftermath of two catastrophic earthquakes in Christchurch that affected personnel and material associated with the production).

The three-hour DVD resulting from these labours is a broadly accessible presentation of Rutherford's life, including a substantial middle portion on the role of Canada in his story. Prof. Campbell's efforts have yielded an important contribution to the public record on this key figure of 20th century science, and in particular, scientific development in Canada.

With this award, Prof. John Campbell is recognized for his valuable contribution to the historical record on the life of Lord Rutherford, and for bringing due (and long overdue) public recognition to the role that Canadian science played in Rutherford's successes – including the first Nobel Prize for an achievement on Canadian soil.

Cheryl Cottrill

Citation

Cheryl Cottrill is the Executive Director of Women in Nuclear (WiN) Canada since it was founded in 2004. Since that time, she has worked diligently to promote the role of women in the skilled trades and in the nuclear industry. She has been an exemplary role model in promoting the fundamental tenets of WiN: educating women in the industry so that they may be better positioned to talk to the public about the nuclear industry and its benefits, to provide professional development to women who work in the nuclear industry today, and to promote science and technical careers to young people, particularly women.

Cheryl was instrumental in developing and maintaining the WiN website which has been declared as the best internet site within the WiN Global organization. This site is accessed by many young women who are seeking skilled trade careers and are inspired by the stories told by the women profiled on the website. Cheryl has also started a blog which is a more personal approach to reaching members of the community and soliciting their input.

Cheryl has used the social media (Facebook and Twitter) to reach out to the young members of our society, and other means of communication that will resonate with our younger generation.

Canadian Light Source

Citation

The Canadian Light Source (CLS) was the first synchrotron in the world to allow high school students to use beamlines for research through the Students-on-the-Beamline (SotB) program. SotB provides an authentic scientific inquiry experience to high school students, connects teachers and students to scientific research and scientists at Canada's only synchrotron, and makes synchrotron science accessible and understandable for teachers so they will include it in their curriculum.

SotB began in 2005 with a single group of students and has since grown to include schools from across Canada. Since its inception, 215 high school students from six provinces and one territory have participated, collaborating with 28 CLS scientists on 24 experiments and using 276 hours of beam time donated by the CLS. The CLS also encourages community outreach through tours of their facilities. Since 2004, over 16,600 students and teachers have visited the CLS for tours and presentations.

As a complement to the experience provided for students through SotB, the CLS also provides training for science educators through an annual workshop. The importance of the SotB program and the educators' workshop is demonstrated by the initiation of similar programs at other facilities around the world.

R. E. Jervis Award

The *R. E. Jervis Award* was established in1992 by former students of Professor Robert E. Jervis of the University of Toronto to honour his achievements. The *Award* recognizes excellence in research and development as well as in overall academic achievement by full-time graduate students in nuclear science and technology. It is now sponsored and administered by the CNS. The award includes a $1,000 bursary.

Sarah Mokry

Citation

As part of her Master's thesis in 2009, Sarah Mokry developed a heat-transfer correlation for supercritical water. This new correlation is the most accurate, compared to 25 others, over a wide range of conditions. It therefore represents an important contribution to the future development of supercritical water-cooled reactors and other Generation IV reactors.

Sarah is continuing her research at UOIT as a PhD candidate. Her research includes comparing larger supercritical-water datasets with the proposed correlation, developing correlation(s) for modelling other fluids (supercritical carbon dioxide and refrigerants), developing a correlation for supercritical-water bundle data, and developing a correlation for deteriorated heat-transfer regimes.

Sarah is an outstanding student with a large number of publications (46 publications: 2 chapters in books, 5 papers in refereed journals, 36 refereed conference proceedings and 3 technical reports), a number of appreciations, certificates and awards including the Akiyama Medal from Japan Society of Mechanical Engineers for the best paper in the Student Track at the largest in the world International Conference On Nuclear Engineering (ICONE-17).

Fellow of the CNS

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.

George Bereznai

Citation

Dr. George Bereznai has been involved with the CNS since its early days when the CNS was establishing itself and was a member of the CNS Council between 1982 and 1984.

Early in his career at Ontario Hydro, George participated in the development of the early mathematical models and software for the first OH training simulator and eventually became manager of the Simulator Services Department. Then he was Ontario Hydro's Business Development Manager for Eastern Europe, a position in which he successfully promoted CANDU technology internationally.

Later George was appointed AECL Chair and Professor in the Department of Nuclear Technology at Chulalongkorn University in Thailand where he developed the Nuclear Engineering curriculum. He developed and delivered courses on CANDU Systems and Operation, with a view to interactive teaching, self-paced distance learning and internet-based course delivery.

On his return from Thailand, George Bereznai became founding Dean of the Faculty of Energy Systems and Nuclear Science at UOIT where he established undergraduate and graduate programs in Nuclear Engineering as well as in Health Physics and Applied Radiation Science and where he continues to support the Canadian nuclear industry and the CNS. He strongly supported the establishment of the CNS

UOIT Branch, which has grown significantly and, with enthusiastic student executives, has become an active and innovative Branch.

CNS President's Award

A number of years ago the CNS Council empowered the President to grant an award of his own discretion. Not all presidents have taken advantage of this authority. In recent years, those presidents who have wished to grant this award have sought the approbation of the CNS Council.

For 2012, Frank Doyle, CNS president for 2011 – 2012, chose to do so. He bestowed his special award on Lorne McConnell. Following is his citation.

Lorne G.W. McConnell

Dr. Lorne McConnell is considered by many to be the guiding hand in the production of electricity from nuclear in Canada. Following his university training at the University of Saskatchewan, interspersed with naval training and radar duty on Atlantic convoys, Lorne spent 10 years from 1945 to 1955 in various roles with Defence, NRC and AECL in Montreal, Ottawa and Chalk River. He started his 35-year career with Ontario Hydro in 1955 and was part of the NPD (Nuclear Power Demonstration) program at CGE in Peterborough prior to moving to the NPD site in 1960. Lorne appears in the historical NPD start-up photograph in 1962 as its first Station Manager.

Lorne McConnell went on to head up all nuclear, and, in due course, all electrical production in Ontario. He pioneered many innovative changes in the electrical production cycle, including staff training and supply chain management. Prior to his retirement from Ontario Hydro in 1990, as VP of Corporate Planning, Lorne led the development of the O.H. long-range Demand/Supply Plan.

Dr. McConnell has been recognized for his many achievements during his long career, including the following awards:

1971 Electrical Man of the Year in Canada, Electrical News and Engineering

1977 Ian F. McRae Award, Canadian Nuclear Association

1978 Engineering Medal, Professional Engineers of Ontario

1980 Distinguished Graduate, University of Saskatchewan

1988 Fellow of the Canadian Academy of Engineering (FCAE)

1989 Quality in Nuclear Power Plant Operations, International Award

It is fitting that Dr. McConnell is being honoured again in 2012 on the 50th anniversary of electricity production by nuclear technology in Canada.

Certificates of Recognition 50th anniversary of nuclear power in Canada

A further special presentation was added to commemorate the 50th anniversary of the first production of electricity by a nuclear plant in Canada, which took place June 4, 1962 at the Nuclear Power Demonstration (NPD).

"Certificates of Recognition" were presented to four of the "pioneers" who were involved

in the start-up of NPD and were present at the conference, as a symbolic action on behalf of the many involved in NPD. The four were: Lorne McConnell; Elgin Horton; Vern Austman; and Fred Boyd.

(See the story of NPD in the March 2012 issue, Vol. 33, No. 1, of the CNS Bulletin.)

NPD "Pioneers" L to R Verne Austman; Lorne McConnell; Elgin Horton; Fred Boyd.

All Award winners pose together for camera.

Cleaning-Up Abandoned Uranium Mines in Saskatchewan's North

By LAURIER L. SCHRAMM, PRESIDENT AND CEO, SASKATCHEWAN RESEARCH COUNCIL

Abstract

Thirty-six now-abandoned uranium mine and mill sites were developed and operated on or near Lake Athabasca, in Northern Saskatchewan, Canada, from approximately 1957 through 1964. During their operating lifetimes these mines produced large quantities of ore and tailings. After closure in the 1960's, these mine and mill sites were abandoned with little remediation and no reclamation being done. The governments of Canada and Saskatchewan are now funding the clean-up of these abandoned northern uranium mine and mill sites and have contracted the management of the project to the Saskatchewan Research Council (SRC). The clean-up activity is underway, with work at many of the smaller sites largely completed, work at the Gunnar site well underway, and a beginning made at the Lorado site. This lecture presents an overview of these operations.

Introduction

Significant uranium mining and milling operations were launched during WWII under the War Measures Act. After WWII uranium mining and milling were kept under federal jurisdiction, under the Atomic Energy Control Act (1946). The Atomic Energy Control Board in turn licensed a number of small mines, plus the larger Gunnar and Lorado mines, in the late 1940s and early 1950s. Most of these mines were located on or near Lake Athabasca, in Northern Saskatchewan, as shown in Figure 1. Almost all of the uranium was sold via Eldorado, a federal Crown Corporation, to the US Atomic Energy Commission. Although the Board licensed these mine and mill sites, they did not impose any decommissioning or reclamation criteria on them when these operations ceased operations in the early 1960s. As a result, little to no decommissioning or reclamation was done between the 1960s and 2006.

In 2006, SRC became responsible for managing the cleanup of these sites, under contract to the Province of Saskatchewan [1]. Our top priority in this work has been to clean-up the sites and make them safe! In doing so it has been SRC's responsibility to develop and implement remediation options that are technically and economically feasible, maintain a financially responsible budget and due diligence (so contract tenders are bid competitively), and ultimately establish a cost-effective environmental monitoring program and minimize long-term care and maintenance at the site. Another goal has been to engage with the northern and Aboriginal communities and, where possible, develop and enable training, employment, and meaningful economic activity opportunities for these local residents.

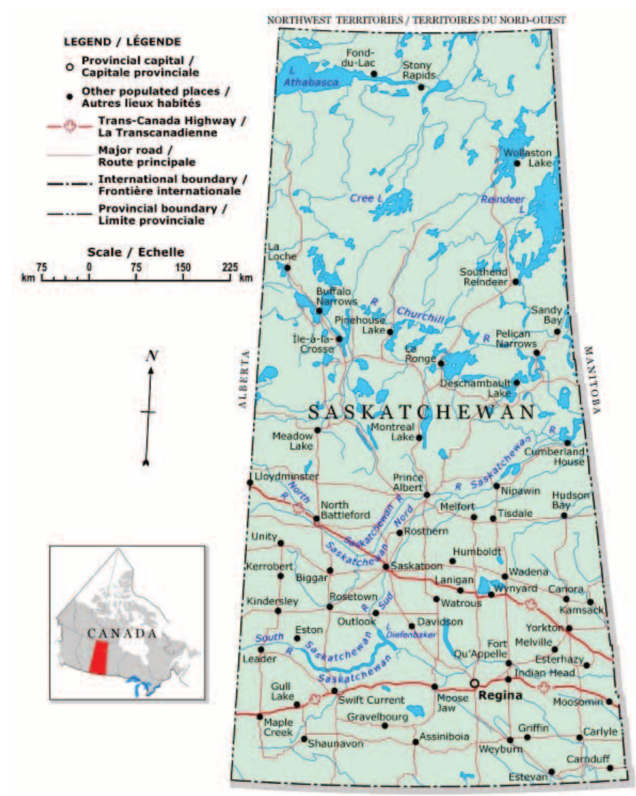


Figure 1. Abandoned uranium mine and mill site region. (Map from Natural Resources Canada, 2001.)

Community Engagement - Beginnings

Although this project has many stakeholders, probably none have had more interests, hopes, and concerns than the local communities: in this case the residents of the Athabasca basin area. Our consultation process has included town-hall meetings, beginning with a full-communities launch town-hall meeting in 2007, and continuing update meetings ever since. Engaging with the mayors and Chiefs and representatives of the local, First Nations, and Métis communities, and with the invaluable advice and assistance of the Prince Albert Grand Council, we were able to establish a Project Review Committee (PRC) in 2008, with representation for each of the local communities: Uranium City, Camsell Portage, Fond du Lac, Stony Rapids, Black Lake, and Hatchet Lake. Also in 2007 we established a relationship with the Northern Saskatchewan Environmental Quality Committee (EQC), which was already in place to provide northerners with a mechanism to learn more about uranium mining activities, environmental protection measures, and the socio-economic benefits being gained in the region. Hosting field-trips for the EQC to the abandoned mine sites enabled community representatives to see first-hand the state of the sites and helped fuel constructive discussions about clean-up options and approaches.

Consultation occurs through public meetings, specific stakeholder meetings, the PRC and EQC, media interviews, information dissemination through radio, newspaper and magazines, a Project CLEANS website and numerous other interactions.

One of the first substantial points of discussion involved the 36 satellite sites and the order in which they would be cleaned-up. A full-community open-house was held in Uranium City early in 2007, at which all of the Athabasca basin residents were invited to learn about the satellite sites, their locations, physical characteristics, and immediate hazards. Following discussions of each site the community residents were invited to provide recommendations on prioritizing the clean-ups and they ultimately recommended groupings of first-, second-, and third-priority sites based on their assessments of proximity and safety hazards. Although SRC had to maintain authority over technical and contractual aspects of the work, engaging with the local communities and following their recommendations on the order of the satellite site clean-ups went a long ways towards gaining their support and "social licence" for our subsequent work on these sites.

Satellite Sites

Some 40 years after abandonment, the satellite sites were found to contain numerous and diverse hazards beyond just the radiation issues that most people would expect. The legacy left behind from the 1960s included multiple mine shaft openings, raises (connecting levels in a mine), and adits (horizontal mine entrances). Although many, if not most of these were sealed at abandonment, 40 years of neglect had taken their toll and many of the original covers had corroded, collapsed, and/or fallen away leaving the shafts, raises, and adits open again. These sites also exhibited:

Figure 2. Example of "before" and "after" views of an abandoned satellite uranium mine site in Northern Saskatchewan (Baska Uranium Mine, 2009.)

- Trenches, unstable ground, and liquid seepages,
- Standing or collapsed wooden/concrete structures, pump-houses, and core racks,
- Concrete pads and foundations,
- Ore carts, fuel tanks, water tanks, boilers (encased in asbestos), and cisterns,
- Extensive amounts of waste rock,
- Miscellaneous debris (vehicle chassis, drill rods, steel casings, barrels, pipes, and rails, etc.), and
- Radiation, asbestos, polychlorinated biphenyls (PCBs), explosives, and unknown chemicals.

Following site surveying, characterization, assessment and options analyses and prioritizations, and gaining regulatory approvals, the satellite site clean-ups have involved such things as:

- Collecting, isolating, and removing hazardous materials,
- Dismantling and removing standing tanks and other structures,
- Removing other substantial-sized debris,
- Backfilling adits, raises and other openings,

- Installing new caps (often stainless steel) on openings, and
- Re-covering the areas to return them to approximately pre-mining-era conditions.

In some cases we were able to deploy relatively new technologies such as the filling of some raises and other cavities with polyurethane foam (PUF). Such foams are well suited to filling irregular openings containing fragmented structural materials, yet offer substantial structural strength when hardened. When capped with natural fill such PUF plugs are essentially invisible.

The first 8 satellite sites were substantially cleaned-up in 2009, the next 5 in 2010, and this work continues, although at a slower pace in 2011 and 2012 due to the ramp-up in clean-up activities at the large Gunnar site as will be discussed below. Figure2 shows a "before" and "after" illustration of work at one of the satellite sites.

Lorado Mine and Mill Site

The Lorado mine and a mill site were commissioned in 1957 and operated until 1960. Lorado Uranium Mining Ltd. used the mill to process ore from its own mine and also from other mines in the area. No decommissioning or reclamation work was conducted upon closure in 1960, but the mill itself was decommissioned in 1990. What remains are the tailings.

The Lorado mill tailings were originally placed in a small "pot hole" near Nero Lake, which eventually overflowed (~335,000 tonnes) into Nero Lake itself, with about 14 hectares of tailings remaining above the high-water line. Work to date has included site surveying, characterization, assessment and options analyses and risk reduction planning. In the meantime, public access has been restricted, and dust control measures have been implemented, including fencing and surface-chemical treatments.

Gunnar Mine and Mill Site

The Gunnar mine and mill site was commissioned in 1955, beginning with an open pit mine that was operated until 1961 and continued with an underground mine until 1964 [2]. In addition to the open pit and underground mines, the mine and mill site included additional mining support facilities and maintenance shops, a uranium milling facility, an acid plant, tailings disposal facilities, and an entire small town including housing, school, hospital, shopping and recreation centres. No decommissioning or reclamation was conducted upon closure in 1964, except that the open mine pit was allowed to flood.

The open pit mine was approximately 300 m long, 250 m wide, and ultimately 116 m deep (Figure 3). The underground mine began production in 1957 and was operated until 1963, by which time it was over 600m deep. The mined ore averaged about 0.15% uranium content, and ultimately nearly 5 million tonnes were produced. Upon closure in 1964, decommissioning was limited to flooding the pit (Figure 4) and capping the shaft. Left behind were:

- a 48m head frame and associated mine shaft,
- a mill housing ore bins, crushing/grinding circuit, thickening circuit, leaching circuit, filtration circuit, clarification circuit, ion exchange circuit, precipitation circuit, and a filtration, drying, and packing circuit,
- laboratories, mixing areas, and storage annex,
- two acid plants and associated storage tanks,
- geology/mine, mine engineering, and heavy equipment maintenance shop buildings,
- water, fuel, and other storage tanks and power generation plants, plus above-ground utilidors for carrying water, sewage and steam, and
- much other unsalvaged major equipment, tanks, concrete floors/pads, structural concrete and steel structures, smaller buildings, scrap steel, and piping.

Figure 3. Gunnar Mine; open pit, circa 1962.

Figure 4. Gunnar Mine; flooded open pit in 2006.

Covering a huge area of the site are over 4.4 million tonnes of tailings and about 500m of the 25 cm diameter wooden-stave pipeline that had been used to transport them [3]. The tailings were originally discharged into a small lake (variously called Blair Lake or Mudford Lake); the tailings eventually overcame the lake (now called Gunnar Main Tailings) and flowed into another basin, Gunnar Central Tailings, which in turn eventually overflowed into Langley Bay (part of Lake Athabasca).

Also covering a substantial area of the site are about 2.8 million m3 of waste rock, covering about 10 hectares [3]. The waste rock is located on the shore of Lake Athabasca and in some locations extends into the water of the lake proper.

Due to the remote location, the Gunnar site was self-contained and provided housing for all single and married employees, plus a school, hospital, community shopping, services, and leisure centre, in order to accommodate about 800 people.

Remote Location Hazards

Working in the North brings its own complexities and hazards due to the remoteness of the locations described above, and to the sometimes severe weather and ground conditions. Spring activities can be limited by getting heavy equipment bogged-down in mud, summer activities by work stoppages or evacuations due to approaching forest fires, fall activities by early onsets of cold weather (-42°C in the fall of 2009) or heavy snow (fall 2010). Getting heavy demolition equipment, a 90-person self-contained camp, and heavy supplies (like 610,000 L of diesel fuel) to the Gunnar site has involved transport over winter ice roads on Lake Athabasca. These ice roads themselves can have an access window as short as a few weeks per year, that are relatively free of crack, heave, melting (thin ice), and storm hazards.

The vast majority of the on-site demolition and clean-up efforts have to be conducted during relatively short summer seasons.

Mine and Mill Site Hazards

The Gunnar site in particular has exhibited a broad range of types and levels of physical, chemical, and radiological hazards.

- Almost all of the buildings of all kinds had suffered leaking roofs, major decay, structural weakening and, in many cases partial ceiling collapses,
- A key hazard was created by the ubiquitous presence of asbestos, which was present in structural steel filler, wall insulation, siding, roofing, pipeline and vessel insulation, various other spray-on applications, and even in cinderblock and general litter,
- Other site chemical hazards included process chemicals like sodium hydroxide, magnesium oxide, calcium hydroxide, vanadium pentoxide, elemental sulphur, and Portland Cement (in quantities ranging from bottles, to barrels, to pallets, to tonnes). Less extensive were occurrences of oils and fuels (and spills thereof), paints, Freon, and PCBs.
- Numerous heavy metals and radionuclides are present in the flooded pit, waste rock, tailings and other areas. Many contaminants of potential concern have been identified [4], the principals being selenium, mercury, and uranium.
- The radiation hazards have been summarized in more detail elsewhere [4]. Many buildings and locations around the site exhibit low gamma radiation levels (i.e., less than about 2 μSv/h at 1 metre), but some of the mill areas, fines piles, tailings areas, and waste rock areas exhibit higher levels. Similarly, some buildings exhibited radon levels requiring action. Both are of concern to a remediation workforce and had to be dealt with.

Gunnar Site High-Hazard Removal

Following triage safety assessments the highest public safety hazards were addressed first. Some of the earliest steps involved securing of the site, and of building entranceways, to limit public access, and development of protocols for safe management of activities on the site. In parallel, hazard warnings were broadly and persistently communicated to all local communities, residents, and businesses.

The hazardous site-chemicals noted above were collected, packaged, and/or segregated depending on the quantities involved. About half of these were removed over the winter ice road in 2012 and sent for proper disposal, while the remainder is expected to be removed over the ice road in 2013. Vast amounts of asbestos were collected, all that could be safely collected in advance of actual building demolition, and packaged for disposal.

The most visible clean-up activities to date involved the demolition of the many (about 84) buildings and standing structures in 2010 and 2011.

Figure 5. Demolishing the Gunnar Head-Frame in 2011.

Figure 6. Example of "before" and "after" views of building demolition at the Gunnar site (2010).

These demolitions included the mine, mill, and plant buildings, school, residences, above-ground utilidors and, of course, the iconic Gunnar head-frame structure (Figure 5).

During this process, constant care had to be taken to protect workers from asbestos, let alone the other hazards, and in many cases buildings had to be maintained under negative air pressure during indoor work (to guard against radon and asbestos), and then constantly sprayed during demolition (to knock-down asbestos dust and fibres). Following demolition the building and chemical materials were collected and transported to holding sites pending ultimate disposal, and the ground covered-over with clean fill (Figure 6).

Consistent with our goal of making the various sites safe, from both public and environmental safety standpoints, it was also an over-riding priority to conduct the clean-up activities themselves as safely as possible. Key project results from the 2010 and 2011 demolition seasons were the achievements of zero lost-time injuries on site among any of our employees or our subcontractors. This has been another huge accomplishment considering the hazards involved, and an aspect that has earned praise from regulators and other key stakeholders [5].

Community Engagement – Scale-Up

As mentioned above, constructive engagement with local communities has been a priority from the outset. At an early stage, training in the tendering process was provided to local community people and companies. To the extent possible, project work was compartmentalized to enable local bidding and participation in a variety of light equipment and other tasks, in order to maximize the use of local companies and local workforces.

As the project neared the demolition phases, training opportunities were made available to all interested

Figure 7. "Before" (upper) and "after" (lower) views illustrating clean-up progress at the Gunnar site (2011). Photos courtesy Woodland Aerial Photography.

Athabasca basin community residents in order to ensure that they could be qualified to work on the demolition and related activities. In 2010 and 2011 fifteen different training courses (equipment operation, safety practices, asbestos removal, etc.) were provided for about 110 northern residents. This was highly successful in that just over half of the 140-person demolition workforce in 2011 comprised local Athabasca-basin residents.

Active public consultations continue to be required as the remaining environmental assessments, remediation options and recommendations are further developed. Traditional knowledge and traditional land use studies are being conducted in order to feed-into this work the context of traditional uses of the area. Similarly, any planning for future land use will be subject to consultation with the local communities.

Next Challenges

Subject to regulatory approvals, it is anticipated that the next major project phases will include:

- Disposal of the demolition materials,
- Capping of the mine shaft and vent raises,

- General site clean-up and additional surveys and characterizations related to the tailings and waste rock piles,
- Installation of a cover on some or all of the exposed mill tailings (Gunnar and Lorado),
- Rehabilitation of the waste rock piles and any other risk(s) as required,
- Re-vegetation of areas of the rehabilitated site as required, and
- Environmental monitoring during and after rehabilitation.

Several of the above aspects provide further potential opportunities to develop and demonstrate new technologies. One is in approaches to revegetation with native species to bring the sites back to close to their original conditions as quickly and effectively as possible, while providing self-sustaining habitats for wildlife. Another area is in the development of water treatment technologies suitable for remote northern sites.

Most of the above next steps will continue to require environmental impact assessments and approvals from the responsible provincial and federal authorities, including the Canadian Environmental Assessment Agency and Canadian Nuclear Safety Commission. Work on the Environmental Impact Assessments (EIAs) for the Gunnar and Lorado sites is currently underway. These will provide detailed descriptions of the sites, existing environmental risks, remediation approaches and their impacts as well as a recommended remediation plans with mitigation measures and projected environmental outcomes. Much of the scientific information required for the EIAs has already been gathered. The remaining study and data needs will be determined by risk assessments and the development of remedial options.

Projected Endpoints

The goal is to have all of the sites remediated in a way that enables future public and traditional use of the sites and surrounding areas with minimal environmental and public safety hazards. However, some areas, such as the tailings management and land-fill sites may not be available for direct public uses such as camping or seasonal habitation.

The endpoint criteria are being developed with the intent of ultimately transferring the sites to the Saskatchewan government's long-term institutional controls program, thus providing long-term management and monitoring.

Conclusion

In the 1950s and 60s uranium mine remediation was not considered to be very important, leading to the abandonment of numerous mine and mill sites, with little or no remediation or reclamation. Now, more than 40 years later, not only are mine remediation and reclamation judged to be very important, but such aged legacy sites have deteriorated, creating even greater hazards to the public and to the environment.

Modern science and engineering is capable of presenting multiple options for dealing with the hazards and the clean-ups, emerging new technologies can help, and best practices continue to evolve. On the other hand this work demonstrates that cleaning-up such legacy hazards from the past can be huge undertaking, and can be tremendously expensive. When not properly planned-for from the beginning, the remediation phase of such industrial development can end-up costing almost as much as the value of the original extracted uranium. A key lesson is that mine and mill remediation and reclamation are best considered, planned-for, and budgeted-for, as part of a comprehensive, full-cycle approach to uranium development.

Wilfrid B. Lewis (1908 – 1987)

W.B. Lewis, for whom this award lecture series is named, is widely considered to be the 'father' of commercial nuclear power in Canada, including the CANDU and NPD reactor systems. Lewis believed that nuclear science and engineering can contribute to society by raising standards of living and improving quality of life, but that the inevitable hazards of developing and using any source of energy have to be properly dealt with [6]. In particular he felt that "[a] nuclear waste disposal area … if properly planned and maintained … need cause no threat to people's health" [6]. SRC's work on the abandoned uranium sites described above demonstrates that society does have the knowledge and the ability to deal with the residual footprint of uranium industry operations and that, if tackled properly and early enough, both public and environmental safety can be restored.

Acknowledgments

The author would like to acknowledge the many scientists, engineers, and technologists, both within the Saskatchewan Research Council and beyond, for the work that has been completed to date, and the work still required, to fully remediate these abandoned uranium mine and mill sites.

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Opinion

Why wind power does not work in Ontario – and the solution

By DON JONES

I haven't noticed the price of Ontario's electricity dropping despite an over- supply of generation and a ten year low in North American natural gas prices. This is mainly because of the Ontario government's misguided policy of promoting more and more wind generation on the grid under the protection of the Green Energy Act. Large amounts of intermittent wind skew the market leading to take-or-pay contracts with the gas-fired generators and the need to export electricity at subsidized give away prices. With more and more intermittent wind turbines, no one would build merchant gas-fired generators in Ontario since they would be operating at low capacity factors and would price themselves out of the market.

Nuclear electricity provides around 60 percent of Ontario demand and hydro about 20 percent leaving 20 percent or so for the rest, that is, mostly inflexible natural gas and unreliable wind under Ontario government authority contracts, with flexible coal coming in at times of peak demand. Without wind on the grid gas would have a better chance of supplying the entire intermediate and peaking load and see an increasing amount of steady operating hours with lower generation costs. More and more wind being added to the grid in these times of continuing low demand result in very low market prices, even negative prices during the frequent periods of surplus base-load generation (SBG). Since wind is completely unnecessary in the first place it would make little sense to provide expensive energy storage, even if this were technically and environmentally achievable.

Since 2009 October Ontario has had feed-in-tariff (FIT) contracts for wind (and wind is mandated to grow from the present 1,700 nameplate MW to over 8,000 MW by 2018 or sooner) and for the small amount of solar and other renewable sources. As well as natural gas and most of Bruce nuclear output being under various kinds of contracts, regulated rates are paid to Ontario Power Generation's (OPG's) nuclear and base-load hydro facilities all of which results in the so called Global Adjustment (GA). This GA accounts for the difference between the present very low market or spot price and the rates paid to contracted and regulated suppliers and is added to the market price to give the generation cost. The GA is by far the major part of the generation cost. The residential homeowner can pay around twice the generation cost when delivery cost and the other costs are added to the bill.

Even without wind any new generating plant in Ontario might still require some kind of guaranteed floor price for its output in order to get built but without wind there would be a better correlation between supply and demand giving a more stable and reasonable market price and the GA would be a lot smaller. Remember, surplus electricity is exported at the market price and the GA is not paid by the importing jurisdiction; it is paid as a subsidy from Ontario consumers!

Most, if not all, the present 1,700 MW or so of wind is under pre-2009 rules and has priority on the grid. It cannot be dispatched off for economic reasons and there are no financial incentives for wind generators to do so. It can only be dispatched off for grid reliability reasons so SBG, after maximizing exports, results in water being spilled at the base-load hydro stations like Niagara Falls and nuclear output being reduced, or even shutdown at Bruce B. This makes no environmental, economic or technical sense.

The grid operator, the IESO, is trying to implement new market rules making all wind subject to its five minute economic dispatch with payment for foregone generation seemingly still undecided - so much for economic dispatch if payments are made. Until this happens any wind generators under FIT rules, and privately operated Bruce B, get paid for foregone generation as at present when requested to reduce power or to shutdown. The Bruce payments could be rationalized as covering the costs for the improvements and wear and tear to the systems used for manoeuvring output. This payment for foregone generation does not apply to the provincially owned OPG which loses money when its hydro output is curtailed and is maybe the reason why it is not keen to manoeuvre it's Darlington nuclear during periods of SBG, like Bruce B presently does and like Bruce A will. In addition OPG's hydro stations that are not under regulated rates are paid the very low market price for their output that is reduced to accommodate expensive wind and even OPG's regulated rates are lower than the contract rates paid to the private suppliers, all reducing OPG's present and future profitability.

These new IESO rules, if approved, will dispatch wind and base-load hydro before nuclear and this will reduce, but not eliminate, the amount of nuclear manoeuvring now taking place. However the root cause of Ontario's dysfunctional grid still remains, and large amounts of expensive unreliable and unnecessary wind that not only result in Ontario not being able to take advantage of the existing very low natural gas prices but is resulting in steadily increasing electricity prices. Subsidized electricity exports, inefficient and costly operating modes of the wind balancing gas-fired generators, spilling clean low cost base-load hydro, powering down clean nuclear and paying for the forgone energy, new transmission infrastructure to connect up wind, and the parts of the so called smart grid needed to incorporate the wind, are all part of the increasing costs due to wind. The real cost of wind to Ontarians is very much more than the 13.5 c/kWh paid to the wind generators. Costs can only go up.

Instead of allowing the IESO to twist itself into knots trying to accommodate unreliable and unnecessary wind onto the grid, a much better approach would be for the government to replace the present unreliable wind and polluting gas combination by more nuclear, reference 1. No additional capacity is needed since wind adds almost no capacity when it is needed anyway. Nuclear can then be manoeuvred to support more nuclear, rather than support wind. **In the future this new or appropriately refurbished nuclear will have to be described as flexible or manoeuvrable and not as base-load.** It has been evident for many years that better nuclear flexibility was needed in Ontario but the industry (AECL/CANDU Energy Inc./CNA/ etc) has failed, and is still failing, to highlight the potential flexibility of CANDU using reactor power and steam bypass.

The report by the Ontario Society of Professional Engineers (OSPE), reference 2, now agrees with the IESO's proposed new rules to dispatch wind ahead of nuclear which is an improvement on its draft report that wanted nuclear to power down to accommodate wind. Wind poses an unnecessary risk to the grid, reference 3, and does little to reduce greenhouse gas emissions, reference 4. OSPE is wrong in not condemning wind, reference 5.

I am not an energy market analyst but that's how I see it.

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[Ed. Note: An earlier version of this article was posted by Steve Aplin at, http://canadianenergyissues.com/2012/06/04/why-wind-power-does-not-work-in-ontario/]

Aerial view of the Darlington Nuclear Generating Station. Photo courtesy of Ontario Power Generation.


SIMULATIONS AS REAL AS
THE NEED FOR SAFETY

A Simple Estimate of Production of Medical Isotopes by Photo-Neutron Reaction at the Canadian Light Source

By B. SZPUNAR[1], C. RANGACHARYULU[1], S. DATÉ[2], H. EJIRI[3]

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Abstract

In contrast to the conventional bremsstrahlung photon beam sources, the laser back scatter photon sources at electron synchrotrons provide the selective tuning capability of photons of energies of interest. This feature coupled with the ubiquitous giant dipole resonance excitations of atomic nuclei promise a fertile ground of nuclear isotope productions. In this article, we present the results of simulations of production of medical/industrial isotopes ^{196}Au, ^{192}Ir and ^{99}Mo by (γ,n) reactions. We employed FLUKA Monte Carlo code along with the simulated photon flux for a beamline at the Canadian Light Source in conjunction with a CO_2 laser system.

1. Introduction

In recent years, there has been a growing interest for the new methods of production of medical isotopes. This led to several proposals of new nuclear reactors and accelerator based isotope production facilities [1-3]. It is to be noted that *the University of Saskatchewan proposal [1] calls for a multipurpose reactor* which can take a few years before it is built and commissioned. *The Sherbrooke proposal [2] seeks to employ proton beams from a cyclotron facility.* They propose to make use of ^{100}Mo(p,2n) reaction to produce ^{99m}Tc of a short half-life $T_{1/2}$ = 6.6 hours.

We suggest that *the modern photon beam facilities such as the laser back scatter systems at the electron synchrotron sources* used in conjunction with salient nuclear excitations have a good potential to produce medical isotopes in a more cost effective way with minimal background radiations. The unique features of the resonant photonuclear isotope transmutations using the laser photons scattered off GeV electrons have been well described in Ref. [4]. This article describes the preliminary Monte Carlo simulations (using FLUKA [5,6] code) for the production of ^{99}Mo, ^{196}Au and ^{192}Ir isotopes, which find extensive applications in medicine. Also, simulations for a proposed laser back scatter parameters in context with the Canadian Light Source (CLS) are described on the example of production of ^{99}Mo, ^{192}Ir and ^{196}Au.

A glance at the nuclear data tables will convince one that several medical isotopes can be produced using photon-nuclear reactions via the giant dipole resonance (GDR) [7] decay by emitting neutrons.

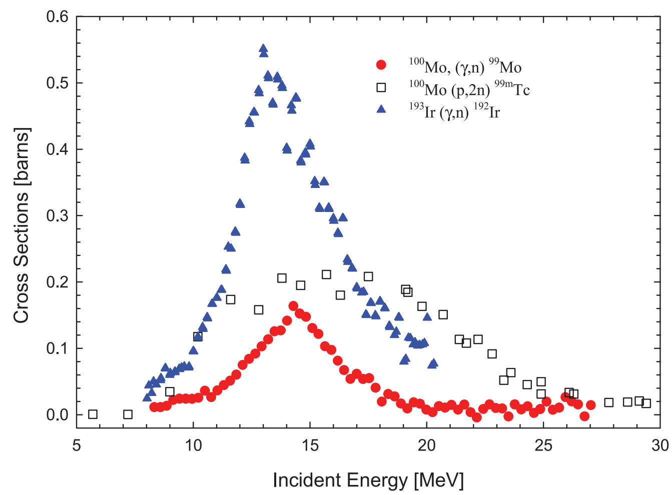

Figure 1: The cross sections for ^{100}Mo (γ,n) [10], (p,2n) [8,9] and ^{193}Ir (γ,n) [11] reactions versus incident beam energy. Data are taken from http://www.nndc.bnl.gov

In Figure 1, the latest measured [8,9] cross sections for (p,2n) reaction (^{100}Mo→^{99m}Tc), are compared with cross section for photo-nuclear (γ,n) reactions for ^{99}Mo (^{100}Mo→^{99}Mo) [10] and ^{192}Ir (^{193}Ir→^{192}Ir) [11]. Some earlier cross section data of ^{100}Mo(p,2n)^{99m}Tc differ from the data of ref. [8,9] by a factor of two.

The note worthy feature in Figure 1 is a maximum cross section at around 14 MeV (≈ $77_* A^{1/3}$ MeV [7], where A is atomic mass) excitation with a width (FWHM) of about 5 MeV (≈ $23_* A^{-1/3}$ MeV [7]). Thus, one should expect enhanced probabilities for the respective (Đ,n) photo-neutron reactions to occur and both photonuclear reactions could be used in production of the respective medical isotopes.

Some examples of calculations were presented by us previously [12] to compare production of ^{99m}Tc isotope by proton beam with the application of gamma ray beam for ^{99}Mo production. The production of Iridium-192, used for industrial applications, can be done by (g,n) reaction with ^{193}Ir (natural abundance ~ 63%) as the target material.

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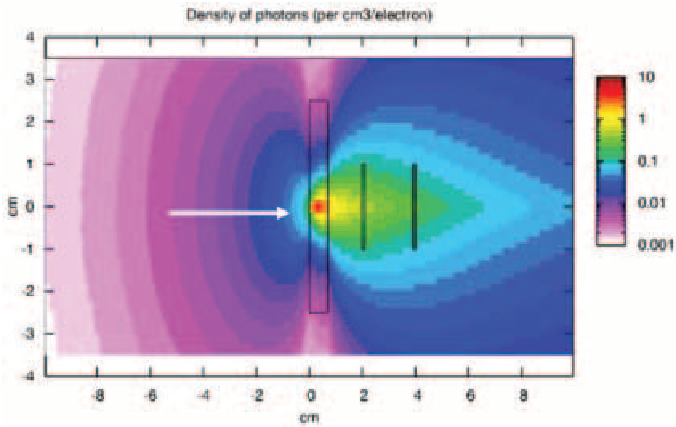

Figure 2: FLUKA simulation (with 1 keV lowest transport limit for photons and electrons) of bremsstrahlung production of photons in 0.7 cm thick, 7 cm diameter tungsten target by 0.5 cm diameter pin electron beam (35 MeV).

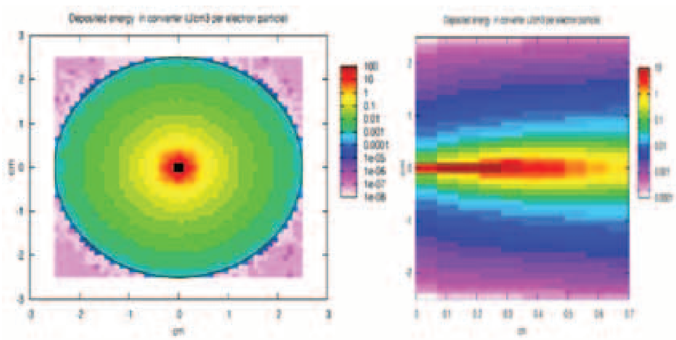

Figure 3: FLUKA simulation of energy density deposited per one electron of 0.5 cm diameter pin electron beam (35 MeV energy) in 0.7 cm thick, 7 cm diameter tungsten target.

Along the same lines, the Prairie Isotope Production Enterprise (PIPE) [3] called for a photon induced reaction $^{100}Mo(\gamma,n)^{99}Mo$ but by using bremsstrahlung radiation from an electron linear accelerator. The idea is based on the work done at Idaho National Laboratory in the 1990s. Additionally preliminary experiments at NRC [13] show that a high-power 35 MeV electron accelerator could produce significant amount of ^{99}Mo for Canada. It is not the intention of this work to repeat simulation of this experiment. However for comparison we performed simplified simulation of bremsstrahlung production of photons in 0.7 cm thick, 7 cm diameter tungsten converter. We used 0.5 cm diameter pin electron beam with 35 MeV energy. In Figure 2 we show simulated density of photons produced per electron. The black horizontal lines indicate the possible ^{100}Mo target positions. They should be positioned very close to the tungsten converter (high photon density) but in real experiment there are restrictions, since the cooling system is required due to the excessive heat produced by the electron beam as shown in Figure 3.

The higher the electron current the more heat is created in the converter and therefore efficient cooling

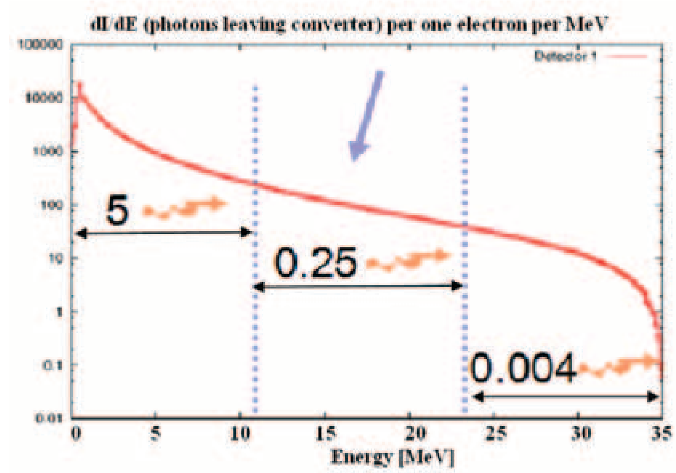

Figure 4: The bremsstrahlung spectrum calculated by FLUKA, plotted as number of photons produced per electron (of 35 MeV energy) in tungsten converter. The 0.25 photons are in the energy region where GDR occurs for the desired transmutation and as indicated by arrow.

system is required. There is large number of photons produced per electron as shown in Figure 4, but only about 0.25 photons per electron for our parameters (35 MeV energy) are in the energy region (indicated by arrow) which can trigger GDR (compare Figure 1) and therefore the transmutation to ^{99}Mo may occur.

The energy of photons is dependent on the setup of experiment and in this example there are a lot of them outside of the energy region of interest which create other isotopes or other undesirable radiation effects. In particular we calculated that there were 0.84 ^{98}Mo nuclei produced per one ^{99}Mo in the ^{100}Mo target, the closest to the converter, while the ratio was 0.93 for the second target.

Currently a high intensity bremsstrahlung radiation using the new electron linear accelerator is under construction at the CLS. More meaningful comparisons of experiment and simulations for production of ^{99}Mo by this method will be possible in the future.

2. Simulation of photon-nuclear interaction at Canadian Light Source

Recently, S. Daté simulated the photon flux for the laser back scatter systems at the CLS. The Klein–Nishina formula [14] was used to calculate back scattered photons energy distribution. We will use it here to estimate the exemplary production of ^{99}Mo, ^{192}Ir and ^{196}Au at CLS. A CO_2 laser used in conjunction with the 2.9 GeV electrons at the CLS will produce photon beams of up to 15 MeV. We will use here the same geometry of targets as proposed by H. Ejiri. To examine the transmutation as a function of depth and photon energy we will use four samples in one row

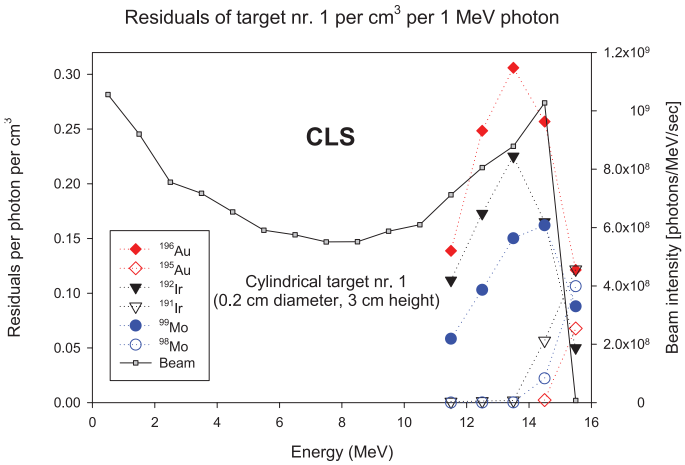

Figure 5: Residuals, calculated by FLUKA, in transmuted ^{197}Au, ^{193}Ir and ^{100}Mo targets per one photon per photon energy (1 MeV width) for given geometry. Also shown is the simulated photon beam intensity for the laser back scatter spectrum at the CLS with a CO_2 laser.

of the same length (3 cm) and 0.2 cm diameter. In Figures 5 and 6 we show residuals and weighted residuals, respectively. They are calculated by FLUKA [5,6] with ^{197}Au, ^{193}Ir and ^{100}Mo targets per one photon, one cm^3 target and with the respective energies (per 1 MeV width) of the simulated photon beam intensity of CLS as shown (Figures 5-6). The low energy cutoff for the transmutation of isotopes of interest is around 4 MeV below the maximum energy. The Figure 5 and 6 present calculations for the target (nr. 1), the closest to the irradiation source.

In Figure 5 one can see that at high energy of photon the ratio of production of ^{98}Mo to ^{99}Mo increases. However unlike the intensity distribution of photons produced by bremsstrahlung, the laser scatter photons shows a sharp cut off above 15 MeV and thus ^{98}Mo production is not significant (see Figure 6).

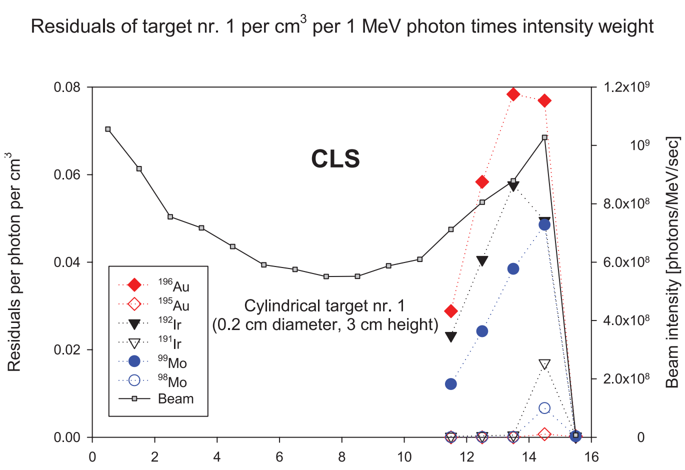

Figure 6: Residuals calculated by FLUKA in transmuted ^{197}Au, ^{193}Ir and ^{100}Mo targets per fraction of photon corresponding to this energy, per one cm^3 with the respective energies of the photon beam intensity as shown and assuming 1 MeV energy width.

Photon flux and the energy spectrum depend on the scattered angle and the target area. If the target is set far from the collision, and the target area is very small there are no low energy photons on the target as demonstrated by the NewSUBARU experiments [4]. While we do not know the total flux of photons produced at the CLS equipped with a CO_2 laser back scatter system, we may assume photon beam intensity of 11×10^9 photons per sec, of which 32% of photons (3.4×10^9 photons per sec) are within 4 MeV top energy window and it will be used to calculate photon induced activity. This spectrum feature is in contrast to bremsstrahlung spectra where we find less than 5% (see Figure 4) photon flux in the region of interest.

The induced activities, during irradiation and cooling time, for ^{100}Mo four all targets (described above) are presented in Figure 7. Using Bateman equations, we calculated weighted residuals (see e.g. Figure 6 for target nr. 1) for the proposed CLS flux and 2.74 days half life of ^{99}Mo.

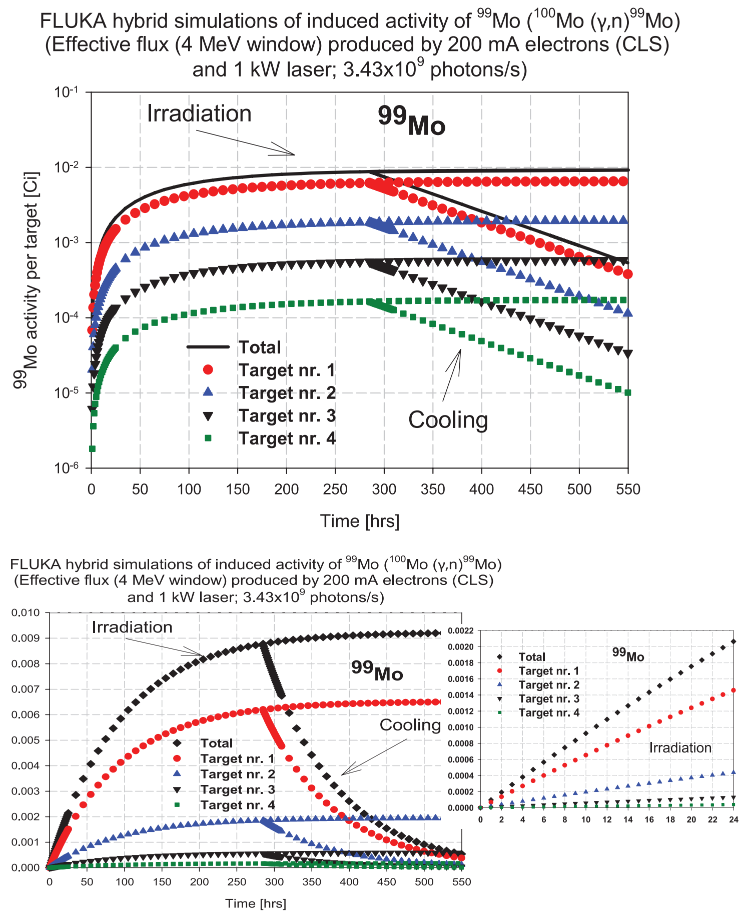

Figure 7: The induced activities of ^{100}Mo four targets (as described in text), calculated numerically using the calculated by FLUKA residuals and the predicted CLS flux and half life time ($T_{1/2}$) of 2.74 days of ^{99}Mo as a function of time. The activity during cooling time is also shown as indicated. The units on the axis of the embedded picture are the same as on the other figures.

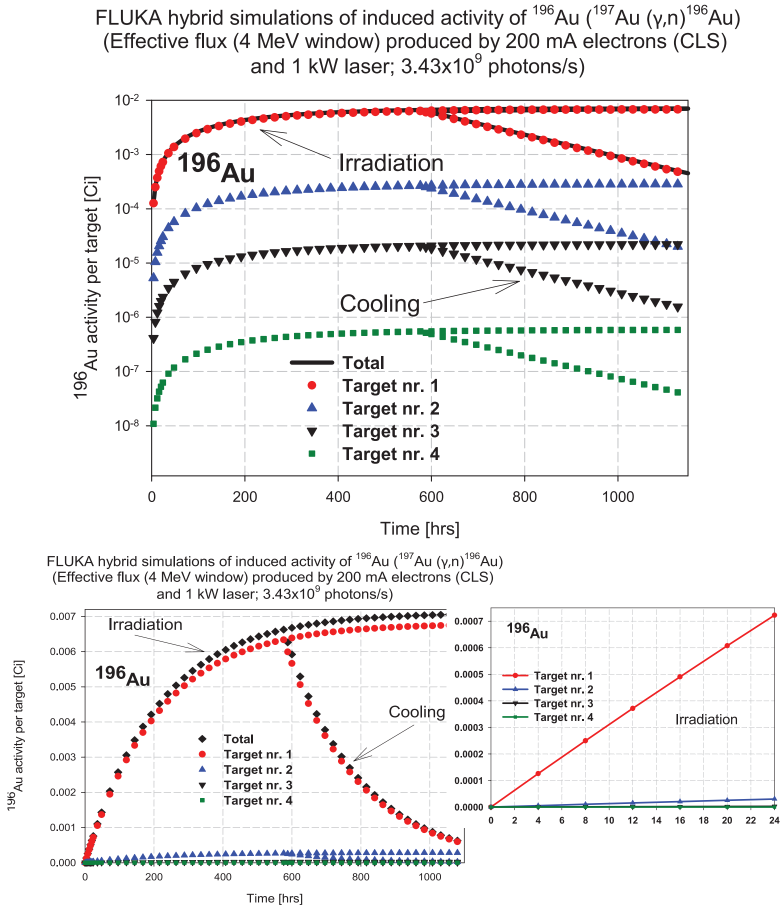

Figure 8: The induced activity per ^{197}Au targets (four targets as described in text), calculated analytically using the calculated by FLUKA residuals and the predicted CLS flux and half life time ($t_{1/2}$) of 6.17 days of ^{196}Au as a function of time. The activity during cooling time is also shown as indicated. The units on the axis of the embedded picture are the same as on the other figures.

The equilibrium state is reached at three times mean time value and as shown in Figures 7-8 stays almost unchanged. When the irradiation stops, the decay will occur with the characteristic mean life (indicated as cooling). As can be seen in Figure 7 the maximum induced activity of ^{99}Mo is too small for commercial production of medical isotopes because of low intensity of photon flux.

In Figure 8 similar calculations of induced activity during irradiation and cooling time are presented for ^{197}Au. Since in this calculations RESNUCLEI detector is used, the contribution from the estimated from FLUKA activity of ^{196}Au isomers is not included. The half-life value equal to 6.17 days is used. When comparing with the previous figure for ^{99}Mo transmutation one can see that it is less useful to employ four targets for the transmutation of heavier elements as for example Au, due to the shorter penetration depth of photons in these targets as seen in the bottom of Figure 8.

3. Comparison of ^{99}Mo yield from ^{100}Mo (γ,n) photonuclear reaction and ^{238}U photofission.

It is known that a ^{99}Mo can also be produced by photo-fission of ^{238}U. In Table 1 the simulated by FLUKA fission yield is shown per 16 MeV photons (the quarter value of the total gamma width of GDR resonance:1.89 eV is used). A cylindrical ^{238}U target of dimensions of 0.012 m diameter and 0.036 m height embedded in lead container is simulated. As shown in Table 1 only 1.17x10^{-7} nuclei of ^{99}Mo are produced directly through photo-fission in ^{238}U and most of the total number produced (1.28x10^{-4}) is produced via (Đ$^{-}$) decay. It is significantly lower amount than obtained by transmutation using GDR for the same geometry and the photon incident energy 14.8 MeV with the quarter value of the total width of GDR resonance (2.5 MeV) is assumed for both beams as presented in Table 2 (1.31×10^{-2}). Nevertheless, FLUKA may underestimate photo-fission [15] future experimental investigation at CLS may, thus, experiment would be useful.

Table 1

^{99}Mo nuclei produced in photofission reaction (see text for details). The last column shows the sum of β^- yield of isotopes (listed in columns 3-8) that lead to the production of ^{99}Mo, while the second column shows direct production of ^{99}Mo.

Photons (16 MeV)	**Fission yield* per one photon [Nuclei/ target]**							β^- yield
Target	**^{99}Mo (42)**	^{99}Kr (36)	^{99}Rb (37)	^{99}Sr (38)	^{99}Y (39)	^{99}Zr (40)	^{99}Nb (41)	**^{99}Mo (42)**
^{238}U	**1.17x10^{-7}**	8.32x10^{-8}	3.94x10^{-6}	1.83x10^{-5}	6.47x10^{-5}	3.46x10^{-5}	6.15x10^{-6}	**1.28x10^{-4}**
Errors (%)	**20.2**	20.5	2.1	1.1	0.9	0.7	2.3	

*This is an order of magnitude estimate as we neglect the neutron branchings of ^{99}Kr and ^{99}Rb.

Table 2

Isotopes produced by the photo nuclear reaction on ^{100}Mo. For target details see the text. The first column lists the reaction and the product nucleus.

(reaction) Product isotope	Yield per one photon	Error [%]
(n,γ) ^{101}Mo$^{\#}$	3.65 x10^{-06}	1.2
(γ,e$^+$e$^-$)$_{atomic}$ ^{100}Mo	7.85 x10^{-05}	0.4
(γ,n) ^{99}Mo	**1.31 x10^{-02}**	**0.03**
(γ,2n) ^{98}Mo	6.06 x10^{-03}	0.1
(γ,3n) ^{97}Mo	9.27 x10^{-05}	0.6
(γ,4n) ^{96}Mo	1.04 x10^{-04}	0.3
(γ,5n) ^{95}Mo	1.56 x10^{-04}	0.2

For the production of ^{99}Mo at CLS natural Mo with 9.6 % of ^{100}Mo can be used because photonuclear reactions on other Mo isotopes produce stable Mo isotopes or the very long-lived ^{93}Mo or very short lived ^{91}Mo, all of which do not disturb ^{99}Mo activity. ^{100}Mo enriched isotopes are also quite realistic to produce by using MoF_6 centrifugal separation as used for example for double beta decays [16].

4. Conclusion

The idea of using MeV photon beams by taking advantage of an ubiquitous feature of nuclear excitations, known as Giant Dipole Resonance (GDR) is explored. The Monte Carlo simulations using the FLUKA demonstrate that the medical isotopes ^{99}Mo, ^{192}Ir and ^{196}Au are the main products of photonuclear reaction on ^{197}Au, ^{193}Ir and ^{100}Mo targets. The production of ^{99}Mo by GDR photoneutron reaction on ^{100}Mo target and ^{196}Au on ^{197}Au target are also explored using proposed parameters for experiment at CLS. It is pointed out that the CLS facility equipped with a CO_2 laser back scatter system will serve as a good testing ground to establish the feasibility of this technique. We conclude that this technique is promising for isotope production at future high intensity photon sources, even if the CLS would not become a commercial facility.

• Acknowledgement

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A CANDU-Type Small/ Medium Power Reactor

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Abstract

This presentation reviews some of the main factors that will govern the design and operation of reactors in remote Northern Canadian communities, as applied to a small CANDU-type power plant. The central advantage of the CANDU is the fact that it is modular at the level of a single fuel channel. Examining each of the main features of this SMR plant on a hypothetical site in the Canadian Arctic reveals some of the unique characteristics that will be either desirable or mandatory for any such power plant applied to service in this remote region.

1. Introduction

The origins of this work go back many years to a comment by John Foster, then President of AECL CANDU, the company now owned by CANDU Energy, Inc. Mr. Foster noted that the CANDU reactor, with its many small fuel channels, was analogous to a wood campfire. To increase the power output, just add more channels, as one does to build a larger campfire. The early development sequence of the CANDU system provides proof of this principle. Three plants were built in succession – NPD-2, Douglas Point, Pickering A − each a factor of 10 larger in power output. This paper returns to a time and a reactor concept near to the first of these three famous power plants.

It must first be noted that this paper is NOT a design description. It is only a "pre-preliminary" design sketch that might serve as a starting point for preliminary engineering. This paper also is NOT a call for more Research and Development. The author has not yet identified any feature of this design that requires, or could benefit from, further research.

New reactors? They all started as small reactors, including the first ones − for example CP1 (Chicago, 1942, with one-half watt of thermal power) and ZEEP (Chalk River, 1945, with up to 50 watts). Canadians were deeply involved in the CP1 experiment as well − Walter Zinn (Queen's and Columbia, 1934) was in charge of building that reactor, and held in his hand a little axe with which to release a shutdown rod into the core if anything untoward happened. George Laurence (Dalhousie and Cambridge, PhD supervisor Ernest Rutherford) carried out the first reactor experiments using graphite and natural uranium in Ottawa in 1939-1941 − but he did not have enough uranium or pure graphite to support a self-sustaining cycle.

We should remember that these were not really the first reactors − the earliest that we know of operated in a uranium deposit in West Africa, some 1.7 billion years ago. Those reactors (a dozen or so) likely operated on natural uranium (about 3.5% U235 at the time) in an oscillatory fashion at a relatively low average power, some for more than 50,000 years.

The Canadian program began with the ZEEP reactor (the first to operate outside the US) but to shorten this story it is sufficient to begin with NPD-2, the first recognizable CANDU-type machine. NPD-2 was started up at Des Joachims on the Ottawa River in 1962. Its power was nominally 20 megawatts electric. It operated successfully for 25 years and was used as a training facility for many CANDU power plant operators. The nuclear portions of NPD are still in place at the original site, but most of the electricity production components have been salvaged.

The next step in development was the Douglas Point Generating Station. It was started up on what is now known as the Bruce Nuclear Power Development site on Lake Huron, in November 1966. Douglas Point was designed to produce 220 megawatts of electricity, about ten times more than NPD2. {The plant was built at a cost of $91 million 1962 dollars, or $413 $/kW(e). The equivalent in today's dollars would be $2930 $/kW(e).}

Douglas Point offered a major learning experience for later power plant designers. Many "little things" went wrong with the plant; these combined to cause a host of performance problems during operation. In fairness it must be mentioned that, by the time Douglas Point was nearing the end of its useful economic life span in 1984, its operating capacity factor had reached a respectable 82 percent. The Pickering "A" plant on Lake Ontario near Toronto was the first direct beneficiary of this experience. Pickering is again ten times larger in electrical output than its predecessor.

At the time the project was committed Pickering represented a prudent upper limit of CANDU reactor size at about 500 megawatts, so four units were built instead of one. The total output of 2168 megawatts was the right size for the Ontario power system. Later units built in Ontario, beginning with Bruce A, were designed both to introduce some variety in design (to reduce the risk of duplicating novel components and systems before they were fully proven by operat-

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ing experience) and to refine the established CANDU design. Maturing regulatory standards also influenced the detailed design of these later plants. The CANDU 6, a medium sized power plant at about 700 megawatts, has been a successful competitor in the international market for the past three decades.

The major disruption of world economies that occurred in the 1970s and more recently in the late 1980s – plus a third economic downturn now in progress have produced remarkable drops in industrial activity, with consequent reduction in electricity demand. This interlude conceals, to some extent, the fact that petroleum prices are now dictated by limitations in the rate of oil supply. It is now generally accepted [1] that new petroleum reserves will become more and more expensive to find and produce. Underlying North American shortages of both oil and natural gas have been hidden by the sudden – and temporary – supply from shale formations.

The International Energy Agency, originally preoccupied with petroleum-based energy, has recently endorsed nuclear energy very strongly as the only means capable of sustaining our current prosperous lifestyle for any length of time into the future [1]. At the same time, it is clearly seen that building a massive fleet of nuclear plants will place a heavy burden on capital markets. Out of these two factors was borne the idea of Small and Medium Reactors (or Small Modular Reactors), so that the incremental capital demand in a given year, for any particular buyer, could be reduced. It is worth noting that this strategy may or may not reduce the TOTAL capital requirement. The lifetime operating costs of several smaller units may actually be higher than those for operation of one larger unit of the same total generating capacity.

Another attractive aspect of the move toward building SMR projects arises from the fact that any large project inclines the buyer to be very conservative in the choice of design details, a natural tendency in view of the high stakes involved. Buyers tend to favor smaller increments of financial risk. It follows that a proposal to build a very small plant – a test reactor – gives the designer an opportunity for innovation that does not exist in the case of a large plant. There is an excellent chance that this strategy might succeed, provided only that there is a productive market for the small plant. The small plant, then serves two purposes – first, as an energy source to meet a specific need and, second, as a prototype from which larger plants might later be developed. Efforts to design and build small reactors give us a second chance to "reinvent" fission power – hence, the "back to the future" aspect of this work.

In order to succeed commercially the design of the small plant (from here on called the Test Reactor) must, of course, meet the needs of its immediate market. If the machine doesn't sell it will never be a good test bed. Table 1 summarizes plant performance specifications appropriate for installation at off-grid sites in Canada's Arctic. These specifications are unique in some ways. The need for security and the absolute necessity to keep components and systems from freezing are especially notable along with the limited potential for regular maintenance. The isolated demand that is implicit at remote sites introduces challenges with respect to load following and/or load leveling. Portability also is an important factor, especially following an initial period of operation at a given location.

Table 1 – Major aSMR System Performance Specifications

- Cost-competitive with petroleum for heating and electricity
- Licensable in Canada, under small-reactor licensing guidelines
- 100% availability (including backup)
- "No-freeze" systems during outage
- Portable in disconnected segments, both as a new and a used facility
- Full range load following – from seconds to days, with energy storage
- Computer controlled operation, plus long-distance remote safety intervention
- Infrequent refueling – minimum one-year sustainability at full power

The market attractiveness of a test reactor must be established to maintain its positive development dynamics. This feature might restrict the freedom to innovate that is required to meet the plant's potential role as a test bed for improving characteristics of the large reactor that is the project's longer-term goal. However, this freedom can be regained by building the test reactor as a modular package of five or six sub-units. In this way, the designer can achieve the objective of portability while at the same time allowing periodic replacement of one or more modules to achieve the flexibility for future innovation.

Large prefabricated sections are best for delivery at a remote site. This dictates a distributed design; that is, a layout that is NOT contained inside a compact containment structure. While this might be considered a drawback for a larger commercial plant, it is not so for a test reactor – partly because of its remote location and partly because of its much smaller size. At a remote site (especially in an extremely cold environment) one would expect the main modules to be placed below grade, to protect them from temperature extremes.

2. Fuel Supply

Fuel supply is always a crucial factor in remote northern communities. Fuel oil delivery and storage now contributes substantially to the cost of northern operations. The same will apply to a nuclear plant. One way to deal with this problem is to design the plant for very infrequent refueling – some designers have claimed a refueling interval of 10 years or longer. This approach certainly has advantages but can introduce significant disadvantages. Some important factors are large "up front" fuel charges, the need for reactivity-suppressing additives in the fuel, and the need to secure valuable fuel from theft. Finally, regardless of the length of the operating interval, refueling involves a major outage with associated problems of shipment of large quantities of fuel both to and from the plant. Perhaps the only satisfactory design solution in this situation is a floating or submersible power plant that can navigate to the shore adjacent to where the power is needed, moor to a prepared base and then connect directly to local power lines. This is the approach currently being implemented in Northern Russia [2].

A second approach to the fuel supply problem is a design with small, relatively inexpensive fuel assemblies. Because of the limited number of CANDU fuel bundles required for each day of operation, this type of reactor fuel is easily transported and stored in the local area. Used fuel of this type also can be transported – in shielded flasks – from the plant site by water or air. The characteristics of this fuel type make it useless to those who might seek to extract dangerous materials for military purposes. The major disadvantage of this approach lies in the need for regular fuel addition and removal, with consequent staffing requirements. There are different ways of dealing with this problem.

The Test Reactor employs a single fueling machine. The automated fuelling system must select a fresh fuel string from storage, carry it to a specific channel, exchange it for a used fuel string, and then transfer the used fuel string to storage. In this design, ten fuel bundles are linked together by a central metal tube. Based on the known fuelling rate of a CANDU 6, a Test Reactor running at half the power density of a CANDU 6 will require about two fresh fuel bundles per day to maintain constant power. Therefore, on average, about one fresh fuel string will be required for each 5-day period at full power. If the fresh fuel store were designed to hold one charge of fuel, or 69 fuel strings, then the reactor could be operated at full power for approximately one year without expert intervention. Such intervention would be required to assemble and place fresh fuel strings into storage racks and to disassemble used strings and store used fuel bundles in the used fuel bay. A roving crew of expert fuel handlers would carry out these tasks. Fresh and used fuel movements to and from the site could be carried out as convenient during the year.

This approach for dealing with frequent refueling recognizes that the power plant will require local skilled technical staff to monitor its operation. Those skills will not be onerous, especially since the machine will be fitted with automatic refueling equipment as well as remote performance monitoring equipment and automatic safety shutdown systems. In any case, installations similar to those required to service communities, mines or military bases must employ trained staff to support their operations. These persons can be trained to conduct limited operations on the nuclear power plant. Performance monitoring can be conducted from a remote location, along with provisions for remote manual shutdown.

Reliability is a paramount consideration at a remote, off-grid site. This requirement becomes essential in conditions of temperature extremes. The essence of any acceptable solution is diversity of supply, either as multiple units of one type or as different types; for example nuclear backed up by diesel with significant storage. The end objective is to achieve a very close approach to 100% availability of energy supply.

Decommissioning raises other issues at any remote location. It appears that the most practical method is to first remove fuel and most other radioactive materials, and then to bury the main structures directly at the plant site. The designer can facilitate this strategy in several different ways, including excavation of disposal spaces directly under the plant before its initial operation. At an appropriate time following final shutdown of the plant, low-level radioactive components then could be lowered directly into this space and then backfilled.

One of the most fascinating questions concerning small and medium reactors is the question of licensing. One should expect that the safety of small reactors to be judged by regulatory agencies in full knowledge that they pose (if properly designed) a smaller risk to the public because of their lower inventory of radioactive materials. This fact has already been recognized to a large degree by the CNSC, as evidenced by their development of a separate set of licensing guidelines [4] that they will apply to low-power reactors. The remaining uncertainty can be expressed in simplistic terms – will the overall cost of licensing proceedings (in both time and money) actually turn out to be roughly proportional to plant risk, or will it remain approximately constant and equal to the cost of licensing a large nuclear plant? This can only be decided by actual experience through licensing and operation of one or more small power plant designs. In today's atmosphere of irrational public fear of everything "nuclear" it will be extremely difficult for a regulatory agency to find in favor of any small plant while using any standards other than the most stringent in existence. It appears that the only way this can be done is through a convincing and comprehensive evaluation of each plant's objective risk.

One way to at least partially resolve this issue is to evaluate the objective risk of each existing nuclear plant, as the basis for assessment of proposed new units. This process bears its own share of risk, because such an explicit comparison would reveal "winners and losers" among the world's nuclear power plants much more clearly

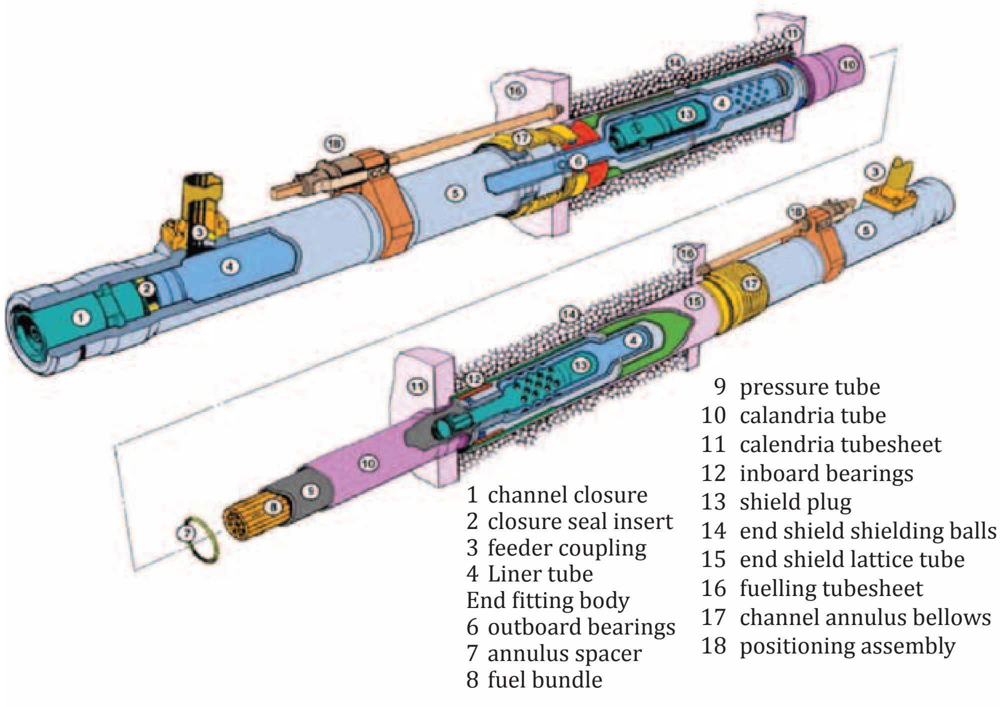

Figure 1 – CANDU 6 Fuel Channel

than does the periodic review now carried out under the International Convention of Nuclear Safety. When judged by the common "*ne plus ultra*" standards of regulation, some plants would likely be required to upgrade. Not to say that this would be a purely negative result, but only to indicate what would surely be an arduous and drawn-out resolution process. Satisfactory resolution of this issue is a precondition for feasibility of small reactors; otherwise, their initial cost may well become unmanageable.

Cost is the final hurdle. Naturally, the first-of-a-kind cost will be higher than that for subsequent units. At the same time, the first unit project is somewhat speculative in nature; this suggests that government sponsorship is the best way to accomplish this step in development. It also suggests that development costs and development time must be kept strictly under control. For this and a number of other reasons, choosing a design that uses well-proven components, and those with which the designers and regulatory agency are very familiar, is the only prudent course.

Cost also is more controllable in an environment where the engineering staff, manufacturers, and potential operating staff are familiar with the technology being proposed. Once again, this suggests that the PHWR technologies embedded in the CANDU power system should be utilized as the starting point for development of any new system.

3. Designing a Purpose-Built CANDU SMR

Figure 1 is a cutaway diagram of the standard fuel channel used in all modern CANDU reactors. With its length reduced from 6 to 5 metres, this channel can produce an average of 5 megawatts (thermal) for one year when fuelled with natural uranium. Replacement of fuel is carried out with the reactor at full power, in about 2½ hours, using a computer-driven, remotely operated fuelling machine. The design process is enormously simplified – just choose the power, select the standard fuel channel and you have the number of channels needed. Using the standard spacing between channels gives the reactor vessel (calandria) size. Then carry on to design all the systems and structures around this basic unit, given the major site parameters. Computer-aided drafting and design packages are easily adapted to detail the final design. All necessary process and structural codes already exist for final design, with minor adjustments to scale.

Following is a brief description of the choices made in designing a 50 MWe SMR for installation at Resolute, a hamlet of 229 people located on Cornwallis Island in the Territory of Nunavut. Its coordinates are 74°41′51″N, 094°49′56″W. Yearly average high temperature is -13 C and the average low temperature is -19 C; the extremes are +18 C to -52 C. The village has four hotels, several lodges, a police detachment, a school, and a gym. The airport is now the largest single facility. Army training facilities may be added in the future. This choice of hypothetical site was made purely for illustration – the purpose being to indicate important plant design choices that must be made to adapt to local site conditions.

This work began from the conceptual design of a small CANDU plant, as designed some years ago by Dr. R.S. Hart [3]. The power output of that design was reduced here by approximately a factor of two to match the perceived needs of an engineering test reactor, and also so that the thermal power would fall within the CNSC definition of a "small reactor" for licensing purposes [4]. The power level of 50 MWe also conforms to the energy demand of a far-Northern air base [5]. At times, much of this demand will be for thermal rather than electrical energy.

CANDU was chosen because (a) it is Canadian, (b) its power output is determined by the number of fuel channels – a number that is almost continuously variable, (c) fuel channel designs are well established and

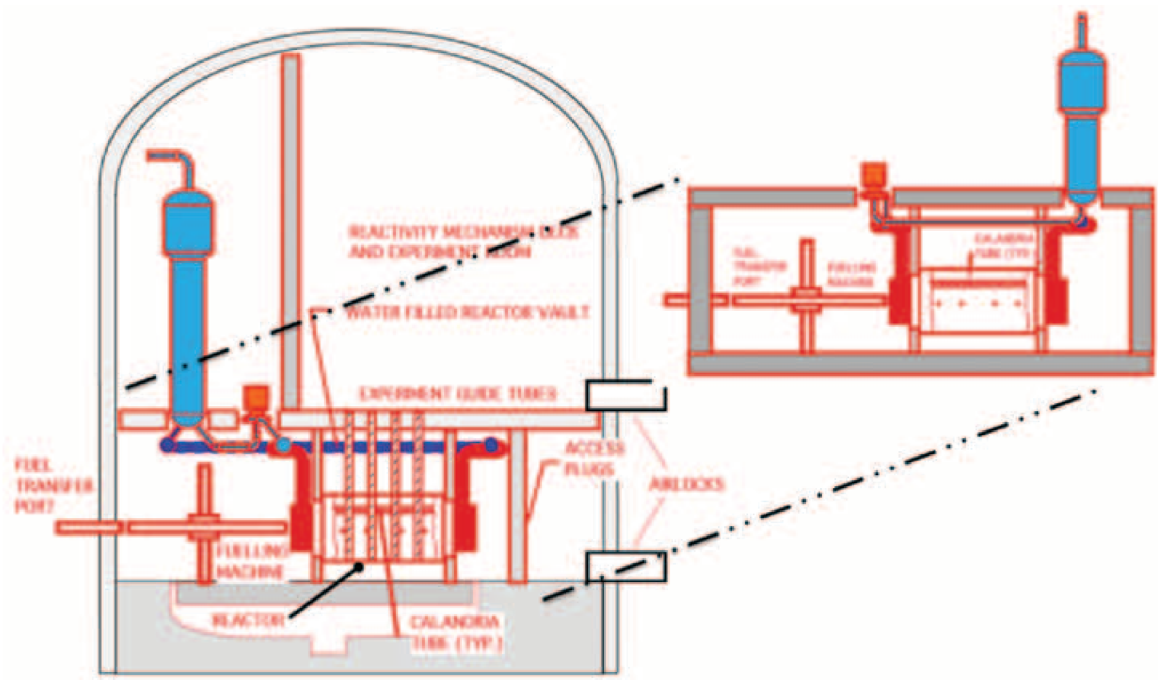

Figure 2(a) – The CANDU ETR **Figure 2(b)** – The SMR Test Reactor

proven in-service, and (d) components and systems other than fuel channels and fuelling machines are relatively simple and do not require exhaustive design effort or testing.

The Figure 2(a) is a sketch of the original ETR [6]. Figure 2(b) is a preliminary sketch of the CANDU-SMR, as presented here. The central systems in the two designs are identical. The main heat transport pumps feature continuously variable synchronous motors, so as to sustain the inlet temperature of the steam generators as the reactor power demand changes.

Aside from the absence of experimental facilities in the SMR, the power output and associated heat-to-electricity sub-systems of these two designs are the same. The containment of SMR has been completely revised to adapt it for underground installation. The new containment borrows the "small box" configuration of the Bruce and Darlington designs. Surrounding compartments (not shown) will be provided for steam pressure suppression. The SMR version shows a reduced height of its steam generators relative to ETR, made so as to reduce the overall plant height. It may prove feasible to further reduce this profile by the use of horizontal steam generators [7].

4. Energy Storage

The next step in developing the SMR design was to account for the variability of power demand that is bound to exist in any isolated installation. Several storage options are available. The method considered here is to add a thermal storage pool (a thermal capacitor) filled with liquid metal or molten salt so that the reactor power can be maintained reasonably constant under conditions of variable power demand (both electrical and thermal). The desirable characteristics of the storage medium are low melting point, high specific heat, and high boiling temperature. The considered choice of fluid is lead-bismuth eutectic. A large storage tank (1200 cubic metres) could store the full power heat output of a CANDU SMR for about 5 hours.

There are several purposes for this storage tank. First, the tank provides a means of smoothing the thermal load from the various local applications, thereby allowing reactor power to be maneuvered much more slowly in response to time-average demand. The second purpose of the storage tank is to "decouple" heat production in the reactor from the sometimes erratic local demands – those demands such as large motor startups and sudden changes in temperature – the "smoothing" function that we have accept without question as the normal function of large, interconnected power grids.

A second source of low-grade thermal energy from the plant is the reject heat flow from the backpressure turbine. Some form of storage facility may be developed to utilize this source; alternatively this energy could serve other purposes such as district heating, runway heating, or water purification.

5. Synthetic Oil Production

Energy storage is an important aspect of any remotely sited SMR project. The storage medium most likely to succeed is liquid petroleum – this is the most convenient form evident in nature; oil produced originally through the fortuitous combination of high pressure in the earth's crust and high temperature produced in radioactive decay of uranium and thorium in the bulk of the earth. The Canadian Arctic now runs mostly on diesel fuel. Cost and availability are accepted today, but some communities are now paying more than ten times the existing rate for electricity and thermal energy commonly paid in Southern Canada. As oil prices escalate in the near future they will open an energy supply niche for appropriately sized nuclear units in the North.

There is a major decision to make before proceeding with the SMR plant design. The options come down to choice of small or large nuclear plant capacity versus lesser or greater distance between the plant and its customers. Small units are attractive in many ways but suffer from a number of disadvantages, as discussed below. Larger units offer lower specific energy cost, but added transport cost from the plant to distant customers comes along with this advantage. One way to control these costs is to locate one or more larger units at a few central facilities such as a air bases, ports, or existing communities and then to convert the plant output into an easily-transported "energy currency" [8] such as synthetic petroleum. (Note: the great-circle distance from Iqaluit to Resolute is more than 5,000 kilometres).

Liquefied natural gas is the most likely source of local, transportable petroleum in the western portion of the High Arctic. Substantial gas resources were discovered in the 1970's; in particular around the Northeast arm of Melville Island. In total, some 18 tera-cubic feet of gas can be made available for use – at least six times the annual consumption in the whole of Canada. These resources are well beyond the economic feasibility limit for shipment to the South. According to Agee [09] economical processes are available for conversion of this gas into various grades of liquid petroleum, including jet fuel. Roughly, these methods consist of steam reforming following by a modern version of the Fischer-Tropsch process.

A second, less desirable source of transportable fuel exists in the Eastern region of the High Arctic, in and around Ellesmere Island. Coal can be liquefied to produce synthetic petroleum. To facilitate this process, one or more nuclear plants could be established adjacent to coal deposits. Coal may, of course be used directly, with the usual worries about production of carbon dioxide and other hazardous wastes. Liquefied coal is more convenient for a number of purposes.

6. CANDU-SMR Advantages and Disadvantages

6.1 Fuelling frequency

Natural uranium fuel, with its low excess reactivity, requires on-power fueling to sustain a steady-state critical system at power. This poses a challenge to the designer at remote sites where it is unlikely a full complement of fully trained operating staff will be in place. Fortunately, CANDU reactors are equipped with semi-automatic fuelling machines. These machines, augmented by redesign to provide for remote operation of new fuel and deposit of used fuel into storage, will be required to reduce the frequency of human intervention. A small group of experienced operators would travel to the site periodically to support the permanent local technical staff. Remote monitoring of plant operation will be designed into the plant, as is discussed below.

Alternatively, it is feasible to add burnable poison to each fuel bundle and to slightly increase uranium enrichment so as to flatten the reactivity versus time curve. Partial thorium loading can produce the same effect, due to its higher internal conversion ratio in a CANDU lattice.

Another way to extend the period between fuelling is to reduce power density – that is, add extra channels to the core beyond the number needed were they to be operated at their potential maximum power. In the Test Reactor, power density is chosen as 50% of that in CANDU 6.

6.2 Fuel Management

The fact that CANDU fuel bundles are small compared with those used in other plant types confers a distinct advantage for the initial installation of the plant, for ease of refueling and used fuel shipment, and for plant dismantling at the end of life. Regular air shipment of new fuel is simple, and flask transport of small amounts of used fuel could be conducted by air or water.

The SMR fuel bundle configuration includes a central tube in which ties a string of bundles together also simplifies remote fuelling. Several fuel strings can be stored adjacent to the reactor vault; these normally will be arranged by the visiting fuelling engineer, and then selected automatically for insertion on the required schedule.

Dry storage of a number of used CANDU fuel bundles is a proven technology. Their low specific concentration of fissile material leads to the realistic conclusion that the possibility of theft is extremely low – their value is far too low to make a CANDU fuel store into an attractive target.

6.3 Operating staff

Commercial power plants require a substantial complement of operation, maintenance, and other support staff. The SMR design must adopt a different approach, purely for reason of operational economics. The first step is to establish a semi-automate design to the fullest extent possible. Computer control of both process and safety systems is predominant in all modern CANDU stations. In the SMR, this must be extended. The second step is to provide extensive remote monitoring capability, utilizing the already-implemented systems-health monitoring systems recently put in place by AECL. The third step is to put in place a two-tier concept of operational staff.

The basic level will constitute resident staff assigned only part time to reactor operation. In addition, a cadre of expert staff who move from one installation to the next on a more or less regular schedule. These staff members will be fully trained and licensed. This supervisory group will be assigned the task of monitoring operation at all existing installations.

6.4 Physical Protection

Remote location of any valuable facility – base, mine, power plant – requires some degree of physical protection against intrusion. In any location within Canada the first rule is the rule of law. Police presence is a necessary part of any civilized settlement in the far North.

Unique isolated circumstances require unique solutions. Surveillance is the first step; we are now in an excellent position to provide wide-area surveillance, thanks to satellite imaging and other electronic intelligence techniques. These tools are supported by rapid response capability via air, land, and water transport.

A nuclear power plant, especially one of CANDU design, is no different from other high-value installations. Its remote location offers an advantage, in that approach by undesirable elements is immediately obvious – there's very little traffic at those latitudes that might provide cover for a hostile group. A few appropriately placed bases or regular sea patrols can provide the necessary response force, supported b wide-area surveillance.

One important point should be added. Realistic assessment of the health consequences of the possible release of radioactive materials from a (deliberately or accidentally) damaged SMR plant will show a much reduced health risk relative to the unrealistic results based on unrealistic reactor licensing conditions that have been applied in the past. Basically, realistic consequence analysis will reveal that even a planned attack on such a plant is useless in terms of resultant health risk to the public. Only an economic risk will remain – and this is not a newsworthy item.

6.5 Proliferation Resistance

As noted above, a CANDU power plant presents essentially a zero risk for diversion of radioactive materials to military purposes – its nuclear fuel is too dilute, too difficult to extract, and simply too heavy to be of any interest to a hostile sub-national group. In addition it is obvious that any hostile group moving about in those remote areas will find concealment to be a nearly impossible task. IAEA safeguard protocols will remain the same for a remote power plant as for a conventional commercial power plant.

6.6 Ease of construction

One important limitation to construction activity is the short summer season in the North. Ocean freighters must deliver sections (modules) of the plant. To somewhat counter this limitation, most of the work at the facility proper will be below grade because the plant will be located underground to protect it from the weather. Underground placement requires either substantially more excavation or extra soil movement from the area surrounding the original surface. Some combination of these two methods is likely, depending on site conditions. The result will be much improved protection from adverse weather conditions as well as from intrusion.

6.7 Maintenance and repair

Obviously, any power plant in a northern installation must have a backup system. In early days the most obvious backup will be one or more diesel generators – and in any case such a backup will be essential to supply the nuclear unit with emergency power. The objective is to achieve essentially 100 percent reliability for "hotel load"; that is, the heat supply required to support proper living conditions, and over 99 percent for electrical supply.

The thermal capacitor (storage tank) can contribute significantly to this reliability – for short periods – but either diesel generators or a second duplicate nuclear unit will be relied upon for the longer term. Note that the presence of a thermal capacitor enhances the good features of auxiliary wind power supply.

6.8 End of life

The assumption concerning decommissioning is that all valuable materials will be removed from the site, either to be used elsewhere in a new power plant or sold for scrap. It is expected that fuel and heavy water will be removed first, to be stored or used elsewhere. Since the plant is located underground the first option for disposal of reactor shell and low-value equipment will be simple backfilling. The designer of a future plant is expected to facilitate decommissioning by the choice of suitable material (low-activity trace elements) and by planning for on-site entombment before the plant is built.

7. Summary

Establishing any power plant, oil or uranium fired, at high latitudes is not a simple matter. When the plant is powered by uranium, the job is a bit different – easier in some ways and harder in others. Given the fact that design specifications can be met by either of these, the choice comes down to all-in cost and product reliability, as well as deliverability.

The very recent experience of the Canadian Remote Power Company [10] offers several lessons regarding this type of project. The company commissioned a careful selection process, did a multi-stage review of market possibilities, and finally selected two candidates – a CANDU-type plant and a prototype naturalconvection PWR. Product deliverability on time, and project cost versus budget were both found to be very important factors in the later stages of review. Finally, market conditions and alternative power supply options for the lead project changed to such an extent that the company suspended the review and selection process. It is obvious that any SMR project in the High Arctic will meet challenges from both technical and commercial alternatives.

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[7] "Design of ART25 Steam Generator", Jesse Saunders, Amjad Farah, Max Kinakin, Scott Massel, UOIT Design Project Report, (2011)

[8] "Smelling Land: The Hydrogen Defense Against Climate Catastrophe", David Sanborn Scott, Cdn. Hydrogen Association, (2007), ISBN 978-11-896881-73-7

[9] "Economic Conversion of Natural Gas to Synthetic Petroleum Liquids", Mark A. Agee, Syntroleum Corporation, Tulsa, (1997)

[10] "Power for Remote Sites in Canada", Presentation by Rex Loesby, President, Canadian Remote Power Corporation, Chalk River Labs, (April 2011)

GENERAL news

(Selected by Fred Boyd from open sources)

OPG Signs Agreements for Possible New Reactors

On June 22, 2012, Ontario Power Generation Inc. (OPG) announced that it had signed agreements with Westinghouse and SNC-Lavalin/Candu Energy Inc. to prepare detailed construction plans, schedules and cost estimates for two potential nuclear reactors at Darlington.

The reports will help inform the government's decision on whether to move forward with new nuclear at OPG's Darlington site.

The Province's Long-Term Energy Plan calls for approximately 2,000 megawatts of new nuclear generation. Two reactor designs are currently subject to the Services Agreements:

- The Enhanced Candu 6 reactor designed by Candu Energy Inc., a unit of SNC-Lavalin
- The AP 1000 reactor designed by Westinghouse.

Under the terms of the agreements, each company will be given 12 months to develop its report. The completed reports will be analyzed and forwarded to the Province for its consideration.

All decisions on whether to move forward with the two potential nuclear reactors will be made by the Government of Ontario.

Fuel Removal Buildings Being Built At Fukushima Daiichi 4

In April 2012 Tokyo Electric Power Company (Tepco) announced plans for the removal of nuclear fuel from Fukushima Daiichi 4.

Unit 4 is heavily damaged and the used fuel pond has had to be supported by the installation of steel beams and concrete. The pond also contains more fuel than the others on site because the entire core load of fuel had been stored there for maintenance work when the natural disasters struck on 11 March 2011.

Unit 4's pond represents one of the biggest hazards on the site, and tackling it by removing the fuel is one of Tepco's highest priorities. However, the equipment normally used for this purpose is damaged and contaminated and there are many tonnes of wreckage on top of the reactor building as a result of the ignition of hydrogen following the tsunami.

To remove the fuel, therefore Tepco will have to finish clearing the debris and then create new shelters fitted with the proper equipment for the work to take place.

Work has already started on a cover for unit 4's reactor building and the company said today it plans to construct another 53 metre steel beam structure over the top of this. It will protect the used fuel pond and the equipment used to remove fuel from the pond and package it. The building will be supported by an 'improved foundation constructed to standards 50% higher than Japanese earthquake codes.

Work has started on the new buildings and these could be finished with equipment fully installed in the second quarter of 2013. The target to actually begin removing the fuel is the latter part of 2013.

The steel platform in place over the used fuel pool of unit 4 (Image: Tepco)

Generator Problem Delays Bruce Unit 2 Startup

In late May 2012 Bruce Power informed that the refurbished unit 2 of the Bruce A nuclear power plant in Ontario, Canada, had been delayed due to damage in an electrical generator on the non-nuclear side of the plant.

Bruce Power had received permission from the Canadian Nuclear Safety Commission in mid-March to restart Bruce A unit 2 following the completion of

The turbine hall of Bruce A unit 2 (Image: Bruce Power)

refurbishment work on the 750 MWe unit. However, during preparations to synchronize the unit to the electrical grid, an unspecified incident occurred which caused damage to the generator. The generator had been replaced as part of the refurbishment project by Siemens Canada. Bruce Power noted that the electrical protection system worked as designed and the approach to connect to the grid was stopped.

AECL Launches New Journal

Atomic Energy of Canada Limited – Nuclear Laboratories has launched Canada's newest journal for nuclear science and technology - **AECL Nuclear Review.**

The new electronic publication will focus on innovative and important nuclear science and technology that is aligned with AECL's core programs.

The Journal welcomes original/novel articles and technical notes in a variety of subject areas: CANDU Nuclear Industry; Nuclear Safeguards and Security; Clean Safe Energy including Gen IV, Hydrogen Technology, Small Reactors, Fusion, Sustainable Energy and Advanced Materials; Health, Isotopes and Radiation; and Environmental Sciences. The accepted peer reviewed articles are expected to span different disciplines such as engineering, chemistry, physics, and biology.

AECL Nuclear Review welcomes Canadian and international research scholars and scientists from different disciplines to the new publication which reflects the integration of scientific researchers and industrial practitioners.

Information on submitting a paper or article can be obtained through the AECL website. The inaugural issue can also be downloaded from the website.

TEPCO Releases Final Investigative Report on Fukushima Accident

On June 20, 2012, Tokyo Electric Power Co., Inc. (TEPCO) released a "final" report based on its own investigations and verifications of the March 2011 accident at the Fukushima Daiichi Nuclear Power Station (NPS) in March 2011.

The report outlines utility's efforts on nuclear safety in the past; describes the magnitude of the earthquake and tsunami that hit the NPS; its impact on the facilities, and its operations based on lessons from the accident.

The report concludes that the loss of all cooling methods was the direct cause of reactor core damage at Units 1 through 3 at Fukushima Daiichi. It also indicates that the fundamental cause of the accident was insufficient preparedness for tsunami, adding that future measures will be based on the concept that "events beyond assumptions can indeed occur."

TEPCO had published an interim report last December.

In addition to issues dealing with the facilities themselves, the final report also aims to pursue the causes of the accident based on facts revealed so far, along with analytical results, and identifies issues in managing facilities relating to the handling of accidents.

The Fukushima Daiichi NPS had originally obtained approval from the national government for permission to install the reactors on the condition that they be designed based on the tidal level of the 1960 Chilean tsunami. Thereafter, TEPCO has implemented voluntary studies and investigations, including the evaluation of tsunami heights based on various sources, including: (1) technological standards of the Japan Society of Civil Engineers, (2) opinions from the Headquarters for Earthquake Research Promotion in the Ministry of Education, Culture, Sports, Science and Technology (MEXT), and (3) trial calculations according to a wave source model of the Jogan Earthquake that struck northeastern Japan in the year 869, and more.

In the report, TEPCO describes its efforts to implement measures given that knowledge and information. The power utility concludes that the "insufficient assumption of tsunami height" was more than just the fundamental cause of the accident, even taking into account that a tsunami is a natural and therefore unpredictable phenomenon. Because it resulted in the subsequent loss of almost all facility functions, it also complicated efforts to bring the accident under control.

(from JAIF)

L-3 MAPPS to Simulate Beznau Nuclear Power Plant Updates

In May 2012, L-3 MAPPS announced that it will proceed with two projects to update the full scope simulator at the Beznau nuclear power plant located in Döttingen, Switzerland. The projects involve simulating the NEXIS and AUTANOVE updates being performed on the plant's two operating units. The simulator updates are expected to enter service in the fall of 2013.

Under the NEXIS project, the Beznau plant is replacing its existing plant information system with an advanced Ovation-based system from Westinghouse. For the AUTANOVE project, the existing remote hydro plant emergency power supply is being replaced with two on-site diesel generators for each operating unit. To properly train Beznau operators on the impact and behavior of these significant plant modifications, the updated simulator must be operational well in advance of the actual plant modifications going into service.

Both updates will be integrated on the full scope simulator and subjected to rigorous on-site testing before the updated simulator is turned over to the plant's training department.

The Beznau nuclear power plant consists of two near-identical Westinghouse pressurized water reactor units. Their net output is 365 megawatts each. The Beznau simulator was put into service by L-3 MAPPS on 30 March 2007.

L-3 MAPPS, a division of L-3 Marine & Power Systems, is located in Montreal. The company has more than four decades of expertise in supplying plant computer and simulation systems for Canadian reactors.

Tyne Engineering opens facility in Deep River

In April 2012 Tyne Engineering, a Burlington, Ontario, engineering and manufacturing company, opened a manufacturing, development and test facility in Deep River, Ontario to support its on-going contracts with Atomic Energy of Canada Limited.

Tyne Engineering has over 20 years' experience in the design and manufacture of complex engineering systems in the fields of process engineering, mechanical engineering, and Instrumentation and Controls for nuclear and tritium-handling industries.

Located in close proximity to the AECL Chalk River Laboratories, the new Tyne facility will be home to some of Tyne's high-tech manufacturing activities including work on hydrogen and oxygen recombination and hydrogen isotope separation technologies.

Tyne Engineering is an established nuclear engineering firm that works in the fields of process engineering, mechanical engineering and instrumentation and controls for nuclear- and tritium-related industries. Tyne is involved in AECL-developed technologies, one of which is the PAR technology, which is a state-of-the-art safety system designed to remove the risk of hydrogen build-up in reactor buildings.

It has collaborated with AECL for over five years in developing a variety of nuclear technologies. Tyne's new facility will strengthen the relationship between the two organizations. Sustainable Development Technology Canada has been a part of supporting the collaboration between AECL and Tyne Engineering through funding opportunities.

With the manufacturing facility in place, Tyne Engineering plans to commence operations in the coming months. Both organizations see significant potential for further collaborations in the near future, helping to stimulate business innovation through the transfer of AECL science and technology to the private sector.

Point Lepreau Generating Station Update

In late May 2012 issued the following statement about the progress towards restart of the Point Lepreau generating Station.

In August 2011, NB Power Nuclear and the Canadian Nuclear Safety Commission signed a protocol agreement related to restoring a satisfactory rating in Emergency Management and Fire Protection Safety and Control. The protocol specified key activities related to Emergency Response Team performance to be undertaken by NB Power Nuclear to demonstrate the acceptability of the fire protection program.

On May 18, 2012, the Canadian Nuclear Safety Commission concluded that the Emergency Response Team performance requirements have now been met. This positive outcome resulted in NB Power Nuclear achieving a satisfactory rating in the area of Emergency Management and Fire Protection Safety and Control.

NB Power has secured the services of Mr. Paul Pasquet of Canadian Nuclear Partners, an organization consisting of experts in the nuclear industry, as it moves to restart and begins to operate the Point Lepreau Generating Station.

Mr. Pasquet has been providing strategic support to the refurbishment project since spring 2011 and has extensive experience operating and managing a multi-unit plant site and returning those plants to service at Ontario Power Generation. He will now serve as interim Site Vice President for Nuclear and Chief Nuclear Officer. Mr. Pasquet will be an asset in assisting NB Power Nuclear to safely return the Station to service and achieving world-class operating performance.

CNS news

Annual General Meeting

The 15th Annual General Meeting of the Canadian Nuclear Society Inc. was held Sunday, June 10, 2012, in the Delta Bessborough Hotel, Saskatoon, Saskatchewan, immediately preceding the opening of the Annual Conference.

There were 31 members present and five proxies filed, meeting the quorum requirement of 30.

Following the call to order and confirmation of a quorum, the Minutes of the 14th Annual General Meeting, held in Niagara Falls, Ontario, June 5, 2011, were quickly approved.

CNS President for 2011 – 2012, Frank Doyle, referred to his report which had been distributed (and is printed in this issue of the Bulletin).

A proposed slate of candidates for the 2012 – 2013 Executive and Members-at-Large of Council was presented by Adriaan Buijs, chair of the nominating committee. Nominations from the floor were invited and one was made by Gravis Jura, for Vinod Chugh. Adriaan Buijs reported that with that nomination the number did not exceed the maximum number of 25 and moved that the slate be accepted by acclamation. The meeting voted in favour of this action. *(The names of the elected 2012 – 2013 Council are printed elsewhere in this issue of the Bulletin.).*

Treasurer Mohamed Younis tabled his report and the financial Statements for calendar year 2011, the fiscal period for the incorporated Society. Following his motion, seconded by Colin Hunt, these were accepted. Younis then moved that Ttimothy Wright be re-appointed as auditor and which was seconded by Hunt and passed.

Just two of the seven prepared and printed Committee reports were presented, one on the Education and Communication Committee by its chair, Jeremy Whitlock and the other on Women in Nuclear by Cheryl ……

Then Frank Doyle invited the 13 representatives of the various Branches who were present to report on their activities. *(A report by the Branch Affairs chair, Syed Zaidi, is included in this issue of the Bulletin.)* .

Len Simpson, Program Chair for 2011-2012 provided a report on the activities of the various Divisions.

There being no further business, the new Council was declared installed and 2012-2013 President, John Roberts, presented a short address on his aspirations for his term of office.(which is included in this issue of the Bulletin).

Following the traditional handing over of the gavel by Frank Doyle to John Roberts the meeting was adjourned just in time for attendees to move to the Conference venue, the TCU Place, for the opening reception.

Frank Doyle (L) passes the traditional presidential gavel to John Roberts following the CNS Annual General Meeting in Saskatoon, June 10, 2012.

Adriaan Buijs (L) presents Frank Doyle a plaque in appreciation of his leadership as CNS President for 2011-2012.

2012-2013 CNS Council

As elected at Annual General Meeting

Executive

President	John Roberts
1st VP	Adriaan Buijs
2nd VP	Jacques Plourde
Past President	Frank Doyle
Treasurer	Mohamed Younis
Secretary	Colin Hunt

Members at Large

Parvaiz Akhtar	Laurence Leung
Parva Alavi	Guy Marleau
Vinod Chugh	Dorin Nichita
Emily Corcoran	Jad Popovic
Shaun Cotnam	Natalie Sachar
Gammage Dan	Nick Sion
Ruxandra Dranga	Ken Smith
Juris Grava	Jeremy Whitlock
Krish Krishnan	Syed Zaidi

President's Report to AGM

Following is the report from Frank Doyle, CNS President for 2011 – 2012 to the Annual General Meeting held in Saskatoon, Saskatchewan, June 10, 2012.

The past year has been very successful for the Canadian Nuclear Society with the delivery of six major conferences and two courses; the publication of the inaugural edition of the Yearbook under the CNS banner; the release of a documentary on Lord Rutherford sponsored by the ENS; the positive outcomes of the Officers' Seminar; and the numerous Branch and Committee activities throughout the year. Our society is vibrant and strong and continues to enjoy excellent support from our members and stakeholders. We can all be proud of what we have achieved over the years and, while the industry and the CNS face many challenges, we can look forward to building on our success and helping to maintain a strong nuclear industry in Canada. I am honoured and proud to have served as the CNS President during 2011-12.

CNS members continued to be engaged throughout the year in assessing the impact of the Fukushima event and disseminating information to our members and the public at large. The CNS was also an interested and active stakeholder in the restructuring of AECL and expressed the need for AECL to remain a viable supporter for the CANDU industry, and stressed the importance of maintaining a research and test reactor at the Chalk River Laboratories.

Throughout the year CNS continued to evolve its Strategic Plan for the future and this was discussed in detail at the Officers' Seminar. Ben Rouben assumed the inaugural role of Executive Director and Jeremy Whitlock assumed the inaugural role of Communications Director. In addition, Dorin Nichita is in the process of establishing the infrastructure to commence publishing a scientific journal to serve the needs of the CNS. Juris Grava and Jacques Plourde have initiated a protocol to better engage and strengthen the Branches and Divisions primarily serving the direct interests of the operating plants (the Design and Materials Division and the Operations and Maintenance Division), Ben Rouben, Syed Zaidi and Mike Taylor continued to help the Branch Executive prepare programs and help with their strategic direction. It was my pleasure to meet with several of the branches during their planned activities for the year and to see the extent of outreach throughout the branches. All these initiatives, consistent with the long term Strategic Plan, are designed to help ensure the CNS continues to serve the needs of our members and stakeholders in a viable and sustainable manner.

June 4, 2012 is a milestone for Nuclear Energy in Canada marking the 50th anniversary of the production of electricity from the Nuclear Power Demonstration (NPD) plant. Throughout 2012 the CNS is celebrating this event in our Branch seminars and in the June conference in Saskatoon. We are honoured to have with us at these events a number of outstanding Canadian Nuclear Pioneers in Canada, including Dr. Lome McConnell, the first NPD Station Manager, Vern Austman, Fred Boyd, Elgin Horton, and Jon Jennekens and others. Participants at these events receive a specially designed commemorative coaster in honour of the occasion. Lorne, Fred, Elgin and Vern will all be at the Annual Conference and will receive special recognition by the CNS.

Looking to the future, the CNS will host the Pacific Basin Nuclear Conference (PBNC) in Vancouver in 2014. This resulted from a successful bid in 2011, and it will be the third time Canada will host this major conference. In our continuing engagement, the PBNC 2014 CNS Organizing Committee contributed significantly to PBNC 2012 in Korea with a plenary paper presented by Dr. Bill Kupferschmidt and additional papers presented by Dr. Ben Rouben and Mr. Juris Grava. I am still to develop a comprehensive strategy to prepare for PBNC. Part of that plan will be to actively engage international partners with our continuing participation in PNC meetings. We will also take the opportunity to promote the PBNC-2014 Conference (19th PBNC) at major international conferences where CNS members have an active presence. Dr. Laurence Leung will represent Canada in the Opening Plenary Session at NUTHOS-9, Kaohsiung, Taiwan in September and will take the opportunity to promote PBNC-2014.

This brief message could only list but a few of the highlights of the year and you will find more on the CNS activities included in the Yearbook, quarterly Bulletin and on our website. I would encourage your active participation in CNS activities and to help foster the enrichment of our Society and our members. Collectively we can make a difference to Nuclear in Canada.

Incoming President's address

Following is the presentation by John Roberts to the CNS Annual General Meeting held in Saskatoon, Saskatchewan June 10, 2012 following his appointment as President for the 2012 – 2013 period.

Good afternoon, Ladies and Gentlemen,

The past year has seen progress with respect to recommendations from the 2008 report on CNS by the Governance / Organization Task Force, a.k.a "Strategic Plan". Specifically we now have an Executive Director – Ben Rouben and a Communications Director – Jeremy Whitlock. In addition the Operations & Maintenance and Design & Materials Divisions under the leadership of Jacques Plourde and Juris Grava are becoming more closely aligned whilst simultaneously increasing engagement of operating utility branches. This initiative was started by the CNS and has been endorsed by nuclear utility executives following the 2011 International Conference on CANDU Maintenance. The initiative will continue with the 2012 International Steam Generator to Controls conference. These international conferences will be held in alternate years.

Federal legislation designed to ensure appropriate financial measures are in place within organisations, such as the CNS, will soon be in force. A review of the legislation (by Colin Hunt) has shown that the CNS meets the requirements of the legislation. During this review it became apparent that some CNS by-laws require to be amended. The AGM is the only forum at which approval to change by-laws can be given. It is my intention to have all the by-laws reviewed, seek endorsement of appropriate by-law amendments by Council, and have a legal review of the proposed new by-laws. This schedule will mean that the by-laws can be sent to CNS membership for appropriate consideration ahead of the 2013 AGM, as required by the bylaws. Ken Smith has kindly agreed to "lead the charge" for this project and will be presenting the schedule and "workdown curve" at the July Council meeting.

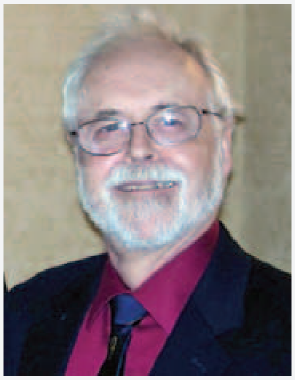
Internationally there a push is for non-profit organisations to collaborate, rather than compete.

As sponsorship, exhibitor and travel budgets shrink the CNS will renew inter-Society agreements within, and external, to Canada.

I hope to visit all CNS branches during my year in office. In addition, members of the executive and the Branch Improvement Initiative will be visiting branches.

Thank-you for coming to attend this AGM and Annual Conference in Saskatoon. Some CNS members are assisting with conference preparations; they submitted their proxy votes. Your presence is helping to make this conference a great success. I look forward to your energy and innovation in helping the CNS through a successful 2012-2013 year and successive years.

Meet the President



As President of the *Canadian Nuclear Society* for 2012-2013, **John Gryffydd Roberts** brings over four decades of experience in nuclear power, demonstrated organization skills, and an enthusiastic energy for the Society and the Canadian nuclear program.

As might be suspected from his middle name, John was born in Wrexham, North Wales. He states he is descended from the ancient royal families of Wales (although he does not display the mannerisms of royalty).

Throughout his involvement in nuclear power John has focussed on chemistry. This began with a "Sandwich Course" at Shell Research's Thornton Research Centre (TRC). Seven years of MAGNOX nuclear power plant chemistry followed at the Trawsfynydd Nuclear Power Station in Wales. He became Second Assistant Station Chemist in 1974; with the accountability for the cooling ponds chemistry and control of liquid effluent discharges. The associated water treatment plants proved to be an interesting challenge and John introduced the concept of routine preventative maintenance (although that term was not then in use).

A fateful trip to Canada in 1976 resulted in John being introduced to CANDU reactors, courtesy of Ontario Hydro. Within a year John was in Canada, having met and married Teresa; an unintended consequence of participation in a bilingual pantomime. (John in a supporting role, Teresa in the costumes department.)

John and Teresa on vacation in France.

Following three years learning about CANDU systems and a trip to Vermont Yankee, John was appointed Station Chemist of the Bruce B four-unit plant in 1980. At Bruce B John was responsible for the chemistry aspects of the construction and commissioning of what he calls his "four Ontario CANDU babies". He convinced Bruce Construction to change their installation procedures, and hydrostatic testing protocols, to benefit plant longevity. (A paper on this was printed in the short-lived CNS Journal in 1986.). Under his leadership the Bruce B Chemistry Laboratory initiated the first Laboratory Quality Assurance program in Ontario Hydro.

Personal interactions with Bruce B Operating and Maintenance staff led to John's Chemistry and Environment staff being augmented. The result was improved Chemistry and Environment programs and a more enjoyable work environment! John recalls the day when he wore his new favourite yellow tie and was stunned to find Bruce B operating staff all wearing hand-crafted yellow ties!

In 1990 John joined the operator licensing program. To his great surprise, in 1992, Bruce B allowed him to join Ontario Hydro International Inc. and off he went to the Cernavoda Nuclear Power Plant in Romania. On his return John continued with Ontario Hydro and subsequently with Ontario Power after the reorganization of the electricity regime by the Ontario government. He states that for much of the late 1990s he was involved with chemical trouble shooting.

In 2001 John chose to join Bruce Power. John arrested active corrosion mechanisms, then specified and oversaw the chemistry for restarting Units 3 and 4. Since retirement last year he has continued as a consultant with considerable involvement with the restart program for Units 1 & 2.

John is a Chartered member of the Royal Society of Chemistry (RSC) and serves on the Radiochemistry Group Committee of that Society. In 2005 John was honoured with the CNA/CNS' Outstanding Contribution Award. The citation described John "as a plant chemist with passion... has always been ahead of his time realizing that good chemistry is the key to longevity...."

In December 2010, John slipped on ice and nearly destroyed his ankle. Although it restricted his mobility it did not stop his activities which included being General Chair of the 2012 CNS Annual conference and his work with Bruce Power. But he acknowledges that Teresa became his feet and hands, his driver, porter and nursemaid. John has been able, slowly, to resume his previous activities, including his love of gardening.

by Fred Boyd with many thanks to Teresa Roberts.

A young John Roberts at Trawsfynydd Nuclear Power Station.

The Financial Statement of the Society for fiscal year 2011 can be found on the Members Only section of the CNS website.

CNS Branch Affairs Annual Report

The following is a slightly edited version of the report by Branch Chair, Syed Zaidi, tabled at 2012 Annual General Meeting held in Saskatoon, Saskatchewan, 2012 June 10)

1. ALBERTA Branch – Duane Pendergast

The Alberta Branch was established in 2007 and has reached a membership of about 50. Many members have been recruited from the student body at University of Calgary through the efforts of Jason Donev. There is a substantial turnover.

Branch members still communicate primarily via the Google Groups facility, email and the occasional teleconference. Membership in the Google Group is holding steady at about 80. Membership includes CNS members from outside Alberta as well as a few guest members with an interest in nuclear energy. A good mix of nuclear experience is thus available within the Group.

Members have been pro-active and creative in seeking out opportunities to fulfil the mandate of the CNS to provide factual information on nuclear technology. Some examples follow.

Educator Initiatives

Jason Donev and Duane Bratt from U of C and MRU, respectively, have both worked diligently to develop courses involving nuclear technology and to engage others with nuclear educational opportunities.

Jason was involved in Pollution Probe and Inside Education energy related workshops. He was able to provide information on nuclear energy that may find its way into future educational initiatives of those organizations. He introduced new methods of teaching into his course; SCIE 42; "An Introduction to Nuclear Power".

Jason also gave a talk at the Calgary Comic Expo on April 28 on "How Science Fiction has affected our View of Science and Technology". People lined up to hear the talk more than an hour ahead of time, and the talk was moved from a room for 50 people to a room for 250 people. Slides are available by request from Jason.

Duane made a presentation titled "Nuclear Energy in Alberta after Fukushima: What now?" to the Centre for Innovation Studies. Calgary, Alberta (May 31, 2011) and was a participant in a Roundtable Forum titled "The Nuclear Menace?" at the *International Student Energy Summit*, University of British Columbia, Vancouver, BC (June 10, 2011) . He spoke to the Frontier Centre for Public Policy and presented papers at the Association of Asian Studies meetings in Toronto (March 18, 2012) and to the 2nd Annual Saskatchewan Mining Conference in Saskatoon (March 28-29, 2012). Duane established a course titled; """The Science and Politics of Nuclear Energy" at Mount Royal University in Calgary. He was engaged in numerous radio and television interviews.

ATA Science Teachers Conference

The "ATA Science Conference 2011" was held in The Fairmont Chateau Lake Louise, from October 20 to 22, 2011. CNS members, Aaron Hinman, Paul Hinman, Rob Varty, Derek Bell and Peter Lang operated the CNS display booth on October 21 and 22 and presented a workshop on October 22, to a group of science teachers.

U of C ISEEE Conference on the Assessment of Future Energy Systems

The U of C's Institute for Sustainable Energy, Environment and Economy sponsored a Conference on the Assessment of Future Energy Systems (CAFES -November 3, 4, 2011). This was a great opportunity to keep nuclear energy on the agenda of a significant Alberta based conference attended by about 200 people. Duane Pendergast, Shaun Ward, Laurence Hoye and Jason Donev participated in the presentations and discussion which are posted on the ISEEE website. ISEEE intends to hold this conference every other year.

Electric Cars

Nigel Fitzpatrick presented on "Hybrid and Electric Vehicle Technology – Developed in BC" to the Pacific Energy Innovation Association Energy on December 7 and to "The State of the Electric/Hybrid Vehicle Industry" at the "Cool North Shore" climate club's "Cool Drinks" monthly get together on January 17.

2. BRUCE Branch – John Krane

Presentations

Frank Doyle (CNS President) presented CNS Overview and Direction

The CNS President gave a presentation at a CNS Dinner Meeting. Topics covered included the CNS Mission, Vision, Objectives, Recent Conferences and Meetings, Strategic Plan and Initiatives.

Juris Grava presented **Operating Utility Engagement Initiative** which is aimed at Improving Operating Utility participation through direct contact between the conference organizers and key Utility executives. A meeting with executives at Bruce Power is being planned.

Meetings

1. One general branch dinner meeting with presentations was held. One Operating Utility Engagement Initiative planning meeting was held.
2. Further meetings are in the planning stage and will focus on presentations by Juris Grava on a Fukushima Update and Emerging Nuclear Countries Update based on Presentations at The Pacific Basin Nuclear Conference held in March 2012.
3. A proposal for new long term nuclear spent fuel storage will be the subject of an upcoming presentation.

Education and Outreach

1. 2 CNS Achievement Awards presented at the 2012 Bluewater District Science Fair (Senior and Junior).

3. CHALK RIVER Branch – Ruxandra Dranga

Executive Committee as of 21 May 2012

Chair:	Ruxandra Dranga
Treasurer:	Alex Trottier
Program Coordinator:	Ashlea Colton
Education and Outreach:	Bryan White
Communications:	Amir Sartipi
Radiation Program at Algonquin College Liaison:	Bruce Wilkin
NA-YGN Liaison:	Natalie Sachar
PEO Liaison:	Dave Wilder
Members-at-Large:	Shaun Cotnam, Rob DeAbreu
NRU Utility Rep	Masih Balouch

CNS-CRB held its Annual General Meeting Oct 2011

Seminars Held:

- Ragnar Dworschak, "Best Theratronics - An AECL Spin-off Success Story": A talk about the Best Theratronics history and product line – providing both a fascinating insight into the world of medical isotopes (in which AECL was a pioneer) and some insight into the physics and engineering issues and solutions in the field today.
- Deep River Science Academy joint lecture series in July 2011:
- Jeremy Whitlock, "Splitting Atoms, Canadian Style".
- David Guzonas, "Supercritical water. What exactly is it?"
- Bill Diamond, "Critical Thinking in Science".
- John Karsaras, " From the Discovery of the Neutron to the Spallation Neutron Source".
- Dr. John C. Luxat, Professor at McMaster University, spoke on the Fukushima Dai-ichi event to a crowd of over 100 people. This event has been co-sponsored with the local Chapter of the PEO.
- Pia Dimayuga (Grade 12 student at Mackenzie High School in Deep River) talked about her summer experience as a participant in the Shad Valley Program.
- Peter Lang, "The Urgent Need for Small Modular Reactors in Canada`s North``. This talk was organized in collaboration with the ZED-2 Reactor Physics Winter School.
- Dr. Tony Noble, Director of SNOLAB Institute - "The Neutrino Enigma and Other Dark Mattes" (organized in collaboration with the ZED-2 Reactor Physics Winter School).
- CNS CRB / NA-YGN CR Chapter - Professional Development Mixer. Speakers / mentors include Bruce Wilkin, Jeremy Whitlock, Gina Strati, Dave Torgerson, Bryan White, Mike Atfield. Event opened only to CNS and NA-YGN members under the age of 35.
- Mr. Frank Doyle spoke on "The future of nuclear in Canada, and the role of CNS, COG and the Chalk River Laboratories" during the CNS CRB 7th President's Dinner.
- Shelley Rolland-Poruks, "Engaging and Working With Our Community". This talk was organized in collaboration with WiN Canada.
- Jay Harris, "Nuclear North of 60". This talk was organized in collaboration with NA-YGN Chalk River Chapter.

Education and Outreach

The table below summarizes the awards, scholarships and programs that have sponsored this year.

	Program / Award / Scholarship 2011-2011	Amount
1	Renfrew County Science Fair 2010 (3 students)	$ 900.00
2	Algonquin College Scholarship (Radiation Safety Program) (3 students)	$1,500.00
3	CNS High School Awards for Academic Excellence ($300 * 7 schools)	
	Opeongo H.S.	$ 300.00
	Madawaska Valley D. H. S.	$ 300.00
	Mackenzie H.S.	$ 300.00
	Bishop Smith Catholic H.S.	$ 300.00
	Fellowes H.S.	$ 300.00
	General Penet High School (Enrichment Fund)	$ 300.00
	Renfrew Collegiate Institute (Enrichment Fund)	$ 300.00

Speakers Juris Grava andJacques Plourde pose with chair Ruxandra Dranga at the May 10 2012 meeting of the Chalk River Branch.

4	Deep River Science - CNS Prize for Excellence in Nuclear Research (2 students)	$ 500.00
5	CNS High School Essay Scholarship (competition)	
	1st price	$1,000.00
	2nd price	$ 600.00
	3rd price	$ 400.00
6	Science Olympics - in collaboration with PEO, Youth Science Ontario, AECL, WiN, NA-YGN, DRSA	$ 300.00
7	Poster Contest	$ 300.00

Deep River Science Academy

- On July 20th 2011, the CNS -CRB organized a movie night for the DRSA students, screening the NRU vessel change from 1974. Prior to the movie, Mike Atfield, Senior NRU Reactor Physicist at AECL gave the students a short lecture on the basics of nuclear engineering and presented a first-hand account of the milestones of the vessel change project.
- Blair Bromley attended the Deep River Science Academy (DRSA) Graduation Ceremony in August 2011 in Deep River, and presented the CNS Awards for Excellence in Nuclear Research to two DRSA Students:
  - Connor Dobson (St. Charles-Garnier High School, Whitby, Ontario) and
  - Naciza Masikini (Pickering High School, Ajax, Ontario)

Expo 150 (June 9 to June 12, 2011)

CNS-CRB Branch Members Blair Bromley, Dave Wilder, Marcel Heming, Dave Wang, Shaun Cotnam, Vic Janzen, Carl Turner, and other CNS-CRB members volunteered to help run a public information booth at Expo 150. This information booth was done in collaboration with the Deep River Science Academy (DRSA), the Professional Engineers of Ontario (PEO) – Algonquin Chapter, the Renfrew County Science Fair, and the Ontario Association for the Certification of Engineering Technicians and Technologists (OACETT). Expo 150 was a large exposition held on June 9 to June 12, 2011 at the Pembroke and Area Airport, and was set up in celebration of the 150th anniversary of the creation of Renfrew County. Over 40,000 visitors attended during the 4-day event. It was an excellent opportunity to reach out to the public, and a missed opportunity for other organizations that declined to participate.

Renfrew County Science Olympics:

On March 3rd the CNS CRB participated in the Renfrew County Science Olympics, along with the PEO, AECL, WiN, Youth Science Ontario, DRSA. The Chalk River Branch will be conducting one of the 4 events, titled "Needling Fruit".

Renfrew County Regional Science Fair (RCRSF)

Three awards were presented in the Nuclear Science and Technology – Special Awards Category:

- Harish Rao – HighView School: What factors improve the efficiency of an electric generator
- Jason Gibson – PineView School: Suntastic Science
- Marianne Couture and Safe Tremblay – St. Mary's School: Geothermal Energy

As part of the RCRSF, we also held our first poster contest for Grade 6-8. The three winners were presented with various science gifs (e.g., Science kit, microscope, etc.). The prizes were won by:

- Bradley Audet
- Akila Senaratne
- Karthik Kannan

Also at the RCRSF, Bryan White had a number of Geiger Counter demonstrations. The students were enthusiastic and asked a lot of questions about nuclear science and technology and really enjoyed Bryan's demonstrations.

Summerfest Planetarium

The CNS / Summerfest Committee and AECL will sponsor a Planetarium during Summerfest 2012, in Deep River. AECL has kindly agreed to allow us to use the Voyageur Room at Keys Campus for this occasion, at no cost. This location is very close to other Summerfest activities.

A projector will be available during this event so that CNS ads can be displayed while people enter and leave the room. The CNS banners will also be posted around the room.

Three 20-minute shows are available for this planetarium.

4. DARLINGTON Branch – Jacques Plourde

In 2011-2012, the Darlington Branch did not hold activities of its own. Some of its 31 members participated in events at the nearby Pickering and UOIT Branches.

It is recognized that both the Darlington and Pickering Branches must focus on increasing the visibility of the CNS at the operating sites by first seeking OPG Senior Management support and then encouraging staff in Operations, Maintenance and Engineering to get involved. A 3-step plan is already underway to address this:

1. To achieve a better alignment with the vision of OPG, and that of its Service Providers located in Durham Region, the Darlington and Pickering Branches will be merged into the **Durham Branch.**
2. The new Durham Branch will fully engage in the 'Operating Utility Engagement' initiative of the NOM and DM Divisions of the CNS, as the vehicle to improve membership and participation in CNS events.
3. The new Durham Branch will work in partnership with the very active and successful UOIT Branch, providing a stronger tie between the students and the operating sites in Durham Region.

5. GOLDEN HORSESHOE Branch (GHB) – Kurt Stoll

Over the past year, the vast majority of the Golden Horseshoe's activities have revolved around planning technical seminars. These seminars seem to be quite popular with our members on campus. A few of our seminars were exceptionally popular, for very specific reasons, and we hope to duplicate these conditions in the coming year.

CNS-CRB Members Dave Wilder and Blair Bromley demonstrating the finer points of electromagnetics.

Our first large success was a seminar on September 20, given by Jean-François Béland, Executive Vice President, AREVA Canada Inc. Approximately 25 people attended and Mr. Béland spent a lot of time discussing the financial considerations nuclear operators make when looking at a new reactor. He also discussed AREVA's presence in Canada and the global market for power reactors. This was a unique seminar for our branch because we rarely have the opportunity to host senior executives of large companies.

On October 21/22 Kurt Stoll (Golden Horseshoe Branch Chair) and Adriaan Buijs (GHB Treasurer) attended the CNS Officer's Seminar at the Marriott Hotel in Toronto. Various CNS policies were discussed and a large number of branch improvement ideas were raised and debated

On November 21, Kurt Stoll attend a free seminar titled "Journalism 101 for Scientists" hosted by the McMaster School of Graduate Studies. Jim Handman (Executive Producer, CBC's Quirks and Quarks), Rob Davidson (TV journalist/producer) and Hannah Hoag (science journalist and editor) were the highlight speakers.

On January 13 Dr.Nitheanandan, Manager of Fuel & Fuel Channel Safety Branch at Chalk River Laboratories, and Chair of the COG Fuel & Fuel Channel Working Group provided an overview of reactor safety R&D at Chalk River. He discussed planned experiments meant to investigate the CANDU moderator's ability to act as a heat sink. The entire McMaster engineering physics (nuclear) graduate student population attended. Dr.Nitheanandan's presentation was particularly valuable for its video content which depicts thermalhydraulic experiments driven to their destructive limit – this was of great interest to those student and faculty at McMaster who conduct research in the thermalhydraulic field.

On January 25, Dr. Victor Snell, Program Director, University Network of Excellence in Nuclear Engineering, gave a presentation to 80 attendees regarding the basic operation and safety of CANDU reactors. The event was held at the Burlington Art Center and the majority of the attendees were senior-level engineers from outside the nuclear industry who were interested in learning more about CANDU reactors and the nuclear industry. Because the audience consisted of established technicians, the questions which followed the presentation were excellent and went so long we had to cut the questioning short.

This event with Dr.Snell attracted three times the typical seminar attendance, and nearly all of these people had never been to a CNS event before. This seminar was co-hosted with the Burlington/Hamilton PEO Chapter and through them we were able to advertise to a new and receptive audience.

On March 29, CNS representatives Kurt Stoll and Stephanie Langton attended the Bay Area Science and Engineering Fair (BASEF) as special awards judges. The Golden Horseshoe Branch donated $400 in prize money "for projects relating to nuclear science and engineering, energy research or climate sciences. The CNS awarded prize monies to four projects judged to be technically exceptional in comparison to their peers: 2 projects related to wind turbine construction and performance evaluation, 1 related to the construction of a microbial fuel cell and another focused on a unique chemical process thought to have applications to vehicle propulsion.

6. MANITOBA Branch– Jason Martino

There was little activity in the Manitoba branch in 2011. Some discussions were held within the branch on a way to revitalize activity within the branch.

7. NEW BRUNSWICK Branch – Brand Nash (By Mark McIntyre)

Unfortunately we are focused on Point Lepreau Nuclear Generating Station, Refurbishment and Return to Service right now. We have not had any events this year.

8. OTTAWA Branch – Mike Taylor

Membership

Membership has remained at a fairly steady level this year.

Executive

This year's executive has been:-

Chair:	Mike Taylor
Past Chair:	Jim Harvie
Program Co-ordinator:	Ron Thomas
Secretary:	Ted Thexton
Treasurer:	Fred Boyd
Webmaster/ Education:	Christine McNally
Members at Large:	Ragnar Dworschak Ruth Brinson Jeet Khosla

Program

1. October 4, 2011-Presentation delivered as the banquet address by Mr. Frank Doyle, President, CNS/ Evening dinner meeting forming part of the 2011 CNS Heavy Water Reactor Conference, Ottawa.
2. November 17, 2011-Joint presentation on the Canadian Society for Senior Engineers initiative: "Energy Compass 2020 – A Recommended Canadian Energy Decision Framework" by Mr. Arnold P. Eyre, Engineering Consultant, and Mr. Don Lawson, former President, AECL CANDU Division – a CNS – CNSC co-sponsored lunchtime meeting.
3. January 16, 2012="Ontario's Long-Term Energy Plan and the Role of Nuclear in Electricity Generation" by Mr. Cedric Jobe, Director, Nuclear Energy Supply Branch, Ontario Ministry of Energy..
4. February 13, 2012-"Bruce 'A' NGS History, the Re-Start of Units 1 and 2, the Continued Safe Operation of Units 3 and 4, and the Future for Bruce Power" by Mr. Norm Sawyer, Executive Vice-President and Chief Nuclear Officer, Bruce Power -Evening dinner and social meeting.
5. April 24, 2012="A Global Perspective on Food Irradiation" by Ruth M. Brinston, Manager of the International Radiation Association.

Members were invited to attend several presentations put on by the CNSC during the year.

Education

This year members have participated in:-

1) Judging a local science fair
2) Manning a CNS stand at a Science Teachers' PD day/meeting

We received considerable help from Bryan White and Jeremy Whitlock. The stand was particularly successful in drawing teacher's interest.

The Geiger kit and the Rutherford DVD were major attractions.

3) Providing a talk on nuclear power to a local high school class.

Website

Once again, our webmaster has done a good job of maintaining the website.

Finance

The Branch finances are in a good state, with sufficient funds to cover the next few months.

Other

Members supported the CNS stand at the CNA Conference in Ottawa. Several executive members attended the CNS Officers meeting in Toronto in October 2011.

We continued active co-operation with the CNSC in terms of speakers and education.

9. PICKERING Branch – Leon Simeon

Branch Activities & Presentations

1. A lunch and learn session was held in Q1-2012, the topic presented was "*Using Neurofeedback for Improving Nuclear Operator Performance*". This technology can be used to improve nuclear operator performance. Frank Doyle, President of the CNS also provided the group with highlights of upcoming CNS events and the goals of the CNS.
2. The Pickering branch attended the UOIT presentation by Dr. Peter Berg. The topic presented was *"Why Not Nuclear? And Why!.* The Pickering branch also got the opportunity to meet the new

executives of the UOIT branch.

3. A lunch and learn session was held in Q2-2012, the topic presented was "Outage Optimization Project at Wolsong, Qinshan, Cernavoda, Point Lepreau, Darlington and Pickering.
4. The Pickering branch attended the "50th anniversary of Nuclear in Canada" at UOIT. Members also got the opportunity to tour the new Energy Research Centre and related laboratories at UOIT in the building.
5. The Pickering Branch attended the Science Rendezvous fair which was held at UOIT.
6. Met with the chair of the Darlington branch and agreed in principle to look at merger with the Pickering branch. The operating branch to be called the CNS Durham branch.

Education and Outreach

1. Dunbarton High School – two students were selected for an award of excellence in science and knowledge of nuclear science. Each recipient will receive $250 from the CNS Pickering branch.
2. Pickering High School – one student was selected for an award of excellence for high achievement in science and knowledge of nuclear science. An amount of $250 will be presented from the CNS Pickering branch.
3. Two Gieger kits were requested for local high schools by the head of the science departments. The schools are located in Pickering and Ajax and provide a great opportunity for outreach to the community. Total expenditure is $847.44.

10 QUEBEC Branch – Michel Saint-Denis

There was only one CNS event for the Quebec Branch this year:

Event:

'The making of the Ernest Rutherford Documentary' – by Dr. John Campbell, Monday, September 12, 2011 at McGill University.

No expenses to report.

11 SHERIDAN PARK Branch – Wei Shen

June, 2011, Branch Seminar:

- Date: Wednesday, June 22
- Title: "Enhanced CANDU 6 (EC6): A Proven Mid-Sized Reactor with Fuel-Cycle Capability"
- Presenter: Michael Soulard
- Director, CANDU 6 Program, Atomic Energy of Canada Limited

September, 2011, Branch Seminar:

- Date: Thursday, September 15
- Title: "Rutherford's Path to the Nuclear Atom" Resource in Fast Reactors"
- Presenter: John Campbell
- B.Sc. (Hons), M.N.Z.I.P., Ph.D.

April, 2012 Peel Region Science Fair:

- On April 15th, representatives from the Sheridan Park branch participated in judging the Peel Region Science Fair held at Louise Arbor Secondary School in Brampton. 5 projects were selected in 3 grade categories in recognition of projects having a connection to energy and/or aspects of nuclear science. The ones marked with an astericks were selected by a larger body of judges to represent the Peel Region School District at the Canada Wide Science Fair that will be held in Prince Edward Island in June:
- **Grades 7 & 8**
  - Jai Aggarwal – "Reversing Radiation: Are Antioxidants the Answer?" (Sherwood Heights School)*
  - Michelle Sun – "Wind Turbines: Horizontal of Vertical?" (Tomken Middle School)
- **Grades 9 & 10**
  - Karishini Ramamoorthi and Ramesh Smruthi – "Prunus Armeniaca: The Fuel of the Future" (Port Credit Secondary School)*
  - Cathy Tie and Katina Zheng – "Biofuel: Here Today, Here Tomorrow" (Glenforest Secondary School)*
- **Grades 11 & 12**
  - **Simran Dhunna – "Thermochemical Energy Storage & Applications: CaO and Ca(OH)2" (Glenforest Secondary School)**

New Executive effective from April, 2012:

Chair:	Wei Shen (wei.shen@candu.com)
Vice Chair:	Peter Schwanke (peter.schwanke@candu.com)
Treasure:	Witty Lai (wlai@ecometrix.ca)
Secretary:	Paul Spagnolo (Paul.Spagnolo@candu.com)
Membership:	Raj Jain (Raj.Jain@candu.com)
Member at large:	Dezi Yang (Dezi.Yang@candu.com)

12 TORONTO Branch – Paul Gillespie

For the period of 2011-2012 the CNS Toronto Branch has held quarterly committee meetings to promote more seminars and additional means of outreach.

Two seminars were held during 2011.

The Toronto Branch has continued to promote the CNS and increase local membership.

Seminars

The following seminars were held during the period of 2010-2011.

- **Peter Ottensmeyer** presented a seminar, "**CANDU Used Fuel "Waste" in Canada: A $36 Trillion Energy Resource In Fast Reactors**", on February 3, 2011.
- **Jerry Cuttler** presented a seminar on "**Is the Supply of More Nuclear Energy to The people of ontario environmentally and socially acceptable**" on March 28, 2011.

Committee

The Toronto Branch general committee was reorganized in late 2011 when Joshua Guin relinquished the role of Chairperson after a number of years in the role. Paul Gillespie is the new Chair however a number of vacancies currently exist which we hope to have filled in the short term.

- Chairperson: Paul Gillespie
- Vice-Chair: (vacant)
- Secretary: (vacant)
- Treasurer: (vacant)
- Utility Coordinator: Saad Khan
- University Coordinator: (vacant)
- Web Master: Paul Gillespie
- General Committee: Mohamed Younis, Joshua Guin, Cory Linton and Andrew Ali

WEBPAGE

The Toronto Branch webpage has been maintained with the most current information regarding seminars to date. Questions can be sent to *Toronto@cns-snc.ca*

13 UOIT Branch – Terry Price

Membership

Current mailing list subscribers: 241
Registered Members: 97
Events Planning Committee: 11 members Active

Events and Activities

A total 15 events were held this term.

Date	Name	Estimated Attendance
07/05/2011	**Booth at Science Rendezvous**	700
06/09/2011	**Nuclear Engineering Student Social**	40
12/10/2011	**Film Night: The Design and Construction of Douglas Point Nuclear Power Station**	12
24/10/2011	**Fast Neutron Reactors - An Unfinished Story**	30
21/11/2011	**Operation Morning Light - The Search and Recovery of Radioactive Debris From Cosmos 954**	30
20/12/2011	**End-of-Year Social**	40
23/01/2012	**Why Not Nuclear? And Why!**	60
27/02/2012	**ADEPT - An Innovative Tool To Reduce Worker Exposure Using Virtual Job Planning**	25
05/03/2012	**Movie Night: NRU Core Removal**	30
07/03/2012	**The IAEA and Global Nuclear Emergency Response**	20
19/03/2012	**Developing an MCNPX model of a DT Neutron Generator at UOIT**	25
21/03/2012	**Celebrating 50 Years of Nuclear Power in Canada**	105
09/04/2012	**End-of-Year Social + Movie Night**	50
12/05/2012	**Booth at Science Rendezvous**	800
14/05/2012	**New Developments in Molten Salt Reactors**	12

Governance

The following were major changes in the operation of the branch:

- Branch elections were held
- A Mandate was created to help guide our branch in its fulfillment of the mandate of the CNS
- An operational guideline was developed
- A mailing list was created
- Relations with the Engineering Society and The Health Physics Association were developed. They are willing to help cosponsor our future events.
- An accounting guideline was created
- Permanent storage space was acquired
- A permanent bulletin board was acquired

Branches celebrate NPD anniversary

Two CNS Branches, UOIT and Chalk River, held special events to mark the 50th anniversary of the start-up of the small Nuclear Demonstration 9NPD0 plant in April 1962 and the generation of the first nuclear powered electricity on June 4, 1962.

The active Branch at the University of Ontario Institute of Technology (UOIT) held their meeting, titled *Celebrating 50 Years of Nuclear Power in Canada* on March 21, 2012 and invited NPD "veterans" to attend. A number from the greater Toronto area did so (see photo). Jon Jennekens, one time president of the Atomic Energy Control Board (predecessor of the CNSC), the invited speaker reviewed the events leading up to the decision to build NPD, the design work at Canadian General Electric and the early operation. About 100 members and visitors attended.

The equally Chalk River Branch held a parallel session on June 20, 2012, in Deep River, with five invited speakers: John Hilborn; Jon Jennekens; JP Letourneau; Lorne McConnell; Fred Boyd, who each gave short vignettes from their association with the project. Again there was a large attendance.

Some of the speakers and a few others, led by Branch Chair Ruxandra Dranga, visited the NPD site, about 20 km west of Deep River, in the afternoon.

Guests of the Chalk River Branch vist NPD prior to the special meeting June 20, 2012.

NPD veterans at UOIT special event, March 21, 2012. L to R: Ted Bazeley; Bob Ivings; Jan Krasnodebski; Gary Vivian; Jim Irving; Dave Bate; Elgin Horton; Jon Jennekens.

Older aerial view of the NPD nuclear generating station near the Ontario Hydro Des Joachims dam on the Ottawa River. Photo courtesy of AECL.

Members honored

Two CNS members were recently honored by other societies.

Dr. John Luxat, Professor at McMaster University and NSERC / UNENE Industrial Research Chair in Nuclear Safety Analyses, was inducted as a Fellow of the **Canadian Academy of Engineering** on June 28, 2012.

The Canadian Academy of Engineering (CAE) comprises many of the country's most accomplished engineers, who have expressed their dedication to the application of science and engineering principles in the interests of the country and its enterprises. The Academy is an independent, self-governing and non-profit organization established in 1987 to serve the nation in matters of engineering concern.

The Academy is an active member of the International Council of Academies of Engineering and Technological Sciences (CAETS), which involves 26 leading countries.

Members of the Academy are nominated and elected by their peers to honorary Fellowships, in view of their distinguished achievements and career-long service to the engineering profession. Members work closely with the other national engineering associations in Canada, and with the other Canadian academies that comprise the Council of Canadian Academies.

Michael Taylor, retired from the Canadian Nuclear Safety Comission and Chair of the Ottawa CNS Branch was named a Fellow of the Canadian Society of Senior engineers (CSSE) at the CSSE Awards Banquet in Ottawa, May 26, 2012.

The citation read:

Mike Taylor has excelled as an engineer in both military and civilian capacities. During his 20 years of service in the United Kingdom's Royal Navy he won the Sir Max Horton Prize for submariners and rose to the rank of Commander. This was followed by 23 years with the Atomic Energy Control Board / Canadian Nuclear Safety Commission. While with the AECB / CNSC, Mike was assigned a series of increasingly responsible assignments, retiring as Executive Director, Regulatory Affairs. He was active in international affairs at both the NEA and IAEA, heading Canada's delegation to the 2^{nd} review of the International Nuclear Safety Convention in Vienna in 2002.

Obituary

William Marriott Brown

Bill Brown, the primary designer of the first on-power fuelling machines for the Nuclear Power Demonstration (NPD) plant, died in Powell River, B.C., March 7. 2012

Bill was born in 1921 in Saskatchewan and moved as an infant with his family to the Okanagan Valley where he grew up in Armstrong, BC. In his early 20s, he joined the Royal Canadian Air Force and was posted to the Shetland Islands during WW II.

On return from overseas he married Marjorie Lorna Berge and completed a degree in Mechanical Engineering at University of British Columbia. After Bill's graduation, they moved to Deep River, Ontario, where he worked for Atomic Energy of Canada (AECL) on the design for the National Research University (NRU) nuclear reactor at the Chalk River Laboratories.

In 1955 he moved to Peterborough, Ontario and took a position with the Civilian Atomic Energy Department (CAPD) at Canadian General Electric (CGE). With CAPD Bill headed the group charged with developing the design of the on-power fuelling system for the NPD 2 design.

After the NPD project Bill continued in CAPD until he was promoted to broader engineering responsibility within CGE.

He retired in 1983 and a decade later.in 1993, Bill and Marjorie moved to Powell River, BC to enjoy their retirement by the ocean and mountains they loved. Marjorie's predeceased him in 2010.

Bill was an active member of the Royal Canadian Legion in Powell River until shortly before his death. Bill is survived by his four children, six grandchildren and two great-grandchildren.

The Council page has been removed from this issue as there has been a query about election and the committee and division chairs have not yet been named.

Canadian Nuclear Society
24th Nuclear Simulation Symposium
PROGRESS IN SIMULATION TOOLS AND METHODS

2012 October 14-16
Ottawa Marriott Hotel
Ottawa, Ontario, Canada

Call for papers

Photo taken at Ottawa October 14, 2006 (© zen! / Flickr)

The Canadian Nuclear Society is organizing its 24th Nuclear Simulation Symposium. The symposium will be held in Ottawa (Ontario, Canada) from October 14 to 16, 2012.

Objective

The objective of the symposium is to provide a forum for discussion and exchange of information, results and views amongst scientists, engineers and academics working in various fields of nuclear engineering.

Topics of interest

The scope of the symposium covers all aspects of nuclear modelling and simulation, including, but not limited to:

- Reactor Physics
- Thermalhydraulics
- Safety Analysis
- Fuel and Fuel Channels
- Computer Codes and Modelling

Guidelines for full papers

The papers should present facts that are new and significant or represent a state-of-the-art review. A clear exposition of the subject should be made in approximately 10 pages. Proper references should be included for all closely related published information.

Submission procedure

Submissions of full papers, preferably in MS Word format, must be made electronically through the symposium submission site:
https://www.softconf.com/c/CNS2012Simulation/

NEW DEADLINES!

Deadline for full papers submission: .... June 30, 2012
Notification of acceptance: .... July 31, 2012
Deadline for final papers submission: ... August 31, 2012
End of early bird registration: .... August 31, 2012

Symposium registration fees (HST included)

	By August 31 / After August 31
CNS Member:	$570 / $640
Non CNS Member:	$670 / $740
CNS Retiree Member:	$200 / $240
Full-Time Student:	$200 / $240

Honorary chair

Dr. Joanne Ball
Director of the Reactor Safety Division
AECL's Chalk River Laboratories

Technical program co-chairs

Dr. Adriaan Buijs
Department of Engineering Physics
McMaster University
e-mail: buijsa@mcmaster.ca
Tel.: (905) 525-9140 ext. 24925

Geneviève Harrisson
Institut de Génie Nucléaire
École Polytechnique de Montréal
e-mail: genevieve.harrisson@polymtl.ca
Tel.: (514) 340-4711 ext. 4120

General questions regarding the symposium

CNS Office e-mail: cns-snc@on.aibn.com
Tel.: (416) 977-7620

Notes to Authors

 For a paper to be presented at the symposium and to appear in the proceedings, at least one of the authors must register by the early bird date.

7th CNS International
Steam Generators to Controls
Conference

Metro Toronto Convention Centre • 11-14 November 2012

SGC 2012 Focusing on

Steam Generators, Heat Exchangers & Heat Transport Architecture
Controls, Valves, Pumps & Electrical
Reactor Components & Functional Architecture

SGC 2012 is a working conference, focusing on what needs attention via:

i) **Issue-Identification and Definition** – as the critically-important Risk-Management Vehicle at the front end of Issue-Resolved Replication for New Build, Re-Build, and Ops-Support

ii) **Technical Excellence Work on Specific Issues** – including the definition of the issue being addressed, and reporting at the end as to the degree to which the issue is satisfied by the work

iii) **Task Leadership Training**

Focus

a. Everything System Architecture and Equipment Related in the Plant
b. Thermal-Hydraulic Architecture and other Essential Competencies
c. Engineering/Process Third Party Audit the Guarantors Can Take to the Bank
d. Establishing Utility Needs: Learning to Listen – Really Listen
e. Configuration-Management – Plant, Equipment and Material Requirements and Specs
f. Degradation – Modes, Root-Cause Investigations, Restoration Strategies
g. Maintainability, Operational Support and Reliability

Program Structure

Mon. 12 Nov. 2012			
Plenary	Steam Generators, Heat Exchangers & Heat Transport Architecture		
Special Technical Sessions	Steam Generators & Heat Exchangers	Controls, Valves, Pumps & Electrical	Reactor Components Configuration Course
Tue. 13 Nov. 2012			
Plenary	Controls, Valves, Pumps & Electrical		
Special Technical Sessions	Controls, Valves, Pumps & Electrical	Steam Generators & Heat Exchangers	Reactor Components Task-Leader Course
Wed. 14 Nov. 2012			
Plenary	Reactor Components & Functional Architecture		
Special Technical Sessions	Reactor Components & Functional Architecture	Steam Generators & Heat Exchangers	Controls, Valves, Pumps & Electrical

Calendar

2012

June 24-28 — **ANS Annual Meeting**
Chicago, Illinois
website: www.ans.org

July 30-Aug. 3 — **ICONE 20 and ASME Power**
Anaheim, California
website: www.asmeconferences.org/ICONE20Power2012

Aug. 26-28 — **3rd Nuclear Education and Outreach Workshop**
Hamilton, Ontario
email: cns-snc@on.aibn.com
website: www.cns-snc.ca

Sept. 9-13 — **9th International Topical Meeting on Nuclear Thermal Hydraulics, Operation and Safety (NUTHOS)**
Kaohsiung, Taiwan
website: www.NUTHOS-9.org

Sept. 19-21 — **CNS Fuel Technology Course**
(location to be determined)
email: csn-snc@on.aibn.com
website: www.cns-snc.ca

Sept. 24-28 — **Nuclear Plant Chemistry Conference NPC 2012**
Paris, France
email: jean-luc.bretelle@edf.fr

Oct. 14-16 — **24th Nuclear Simulation Symposium**
Ottawa, Ontario
Contact: CNS Office
email: cns-snc@on.aibn.com
website: www.cns-snc.ca

Nov. 7-9 — **2nd International Technical Meeting on Small Reactors**
Ottawa, Ontario
email: cns-snc@on.aibn.com
website: www.cns-snc.ca

Nov. 11-14 — **7th International Conference on Steam Generators, Heat Exchangers, Pumps, Valves and Controls (SCG 2012)**
Toronto, Ontario
Contact CNS office
email: cns-snc@on.aibn.com
website: www.cns-snc.ca

Nov. 11-14 — **ANS Winter Meeting and Nuclear Expo**
San Diego, California
website: www.ans.org

2013

May 12-17 — **15th International Topical Meeting on Nuclear Reactor Thermal Hydraulics (NURETH 15)**
Pisa, Italy
email: dlshubring@ufl.edu

May 27-29 — **3rd Climate Change Technology Conference**
Concordia University, Montréal, Québec
(Organized by EIC including CNS)
website: www.cctc2013.ca

June 9-12 — **34th Annual Canadian Nuclear Society Conference**
Toronto, Ontario
email: cns-snc@on.aibn.com
website: www.cns-snc.ca

Aug. 18-23 — **SMiRT 22nd International Conference on Structural Mechanics in Reactor Technology**
San Francisco, California
Call for Papers
website: www.smirt22.org

IAEA publication on Thorium

Role of Thorium to Supplement Fuel Cycles of Future Nuclear Energy Systems

IAEA Nuclear Energy Series No. NF-T-2.4

The investigation of the thorium fuel cycle (ThFC) is a collaborative INPRO (International Project on Innovative Nuclear Reactors and Fuel Cycles) activity within its main area on global vision on sustainable nuclear energy for the 21st century. The current publication reports on the sustainability of nuclear power by re-examining the potential of thorium-based fuel cycles to support future large scale deployment of nuclear energy systems by increasing the availability of nuclear material. Special attention is paid to the thorium fuel cycle from the point of view of economics and proliferation resistance.

STI/PUB/1540; 157 pp.,103 figs; 2012; ISBN 978-92-0-125910-3; English; 36.00 Euro

The electronic version can be found:

http://www-pub.iaea.org/books/IAEABooks/8703/Role-of-Thorium-to-Supplement-Fuel-Cycles-of-Future-Nuclear-Energy-Systems

That Was Then

by Jeremy Whitlock

In honour of the 50th anniversary in June 2012 of Nuclear Power Generation (NPD) at Rolphton, Ontario, and the birth of nuclear-generated electricity in Canada, we reprint this poem first published five years ago on the occasion of the 50th birthday of NPD's older cousin, the NRU.

In days of old
When men were bold,
And neutrons weren't invented,
We stoked our fires
On carbon pyres,
And felt ourselves contented.

While Rutherford bleat
That as for heat,
His atoms were a Bohr,
'Twas Meitner's muse
Lit Fermi's fuse,
And the beggars won a war.

Came C.D. Howe
To take a bow,
For Canada played a role,
In Montreal
They caught the ball
(But didn't catch the Mole).

Laurence's pile
Was all the while
The first, but quite sub-par,
Kowarski's ZEEP
Ran cold and deep
And critically raised the bar.

To Lewis came spoils
Of wartime toils,
When Cockroft's job was done,
'Twas time for dreams
Of Brockhouse beams,
And cancer on the run.

Past Oiseau Rock
Began to flock,
Young scientists in the know,
On NRX
They craned their necks
To see how far they'd go.

They did so well,
A.E.C.L.
Was born to lead the show,
Barely weaned,
"100" cleaned,
It said "Okay, let's go!"

The NRU,
Conceived and grew
Of vision cobalt-plated,
When brains unleash
There is no niche
That can't be dominated.

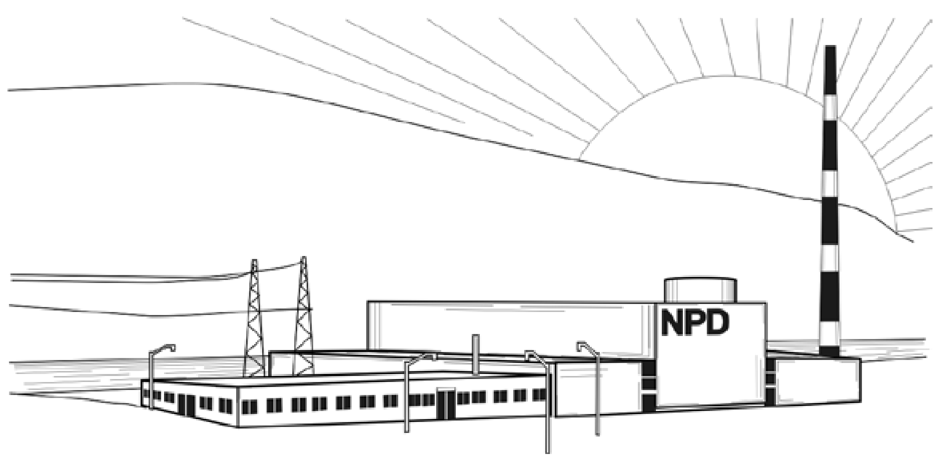
Young mountaineers
Defied frontiers,
With nuclear fire in the belly,
Peaks unclear,
None showed fear,
But Ewan et al turned to Ge(Li).

Laurels reaped,
Discoveries heaped,
A Nobel Prize belated,
The Quest was still
The best until
Summarily spallated...

Pollution free
Electricity
Emerged the driving goal,
Natural U
CANDU it too,
With Canadian heart and soul.

Foster's team
Designed the dream,
McRae and MacKay got it done,
Howey led
The thoroughbred,
And McConnell's crew let it run.

And now, ensconced
And renaissanced,
It's days of old again.
'Tis time for dreams
Once more it seems,
Onwards, women and men!



Call for Abstracts

2nd International Technical Meeting on Small Reactors

2012 November 7-9
The Albert at Bay Hotel, Ottawa, Ontario CANADA

"Celebrating NPD's 50th Anniversary"

Objective

Atomic Energy of Canada Limited (AECL) and Canadian Nuclear Society (CNS) are hosting the 2nd International Technical Meeting on Small Reactors. There is growing international interest and activity in the development of small nuclear reactor technology. This meeting will provide participants with an opportunity to share ideas and exchange information on new developments.

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 power generation and research. A special session is planned to focus on small modular reactors (SMR) for generating electricity and process heat, particularly in small grids and remote locations. On the last day of the Technical Meeting (November 9), AECL will host a tour of the Chalk River Laboratories for all interested attendees. The tour will include the ZED-2 and NRU reactors.

Following the success of the first Technical Meeting in November 2010, which captured numerous accomplishments of low-power critical facilities and small reactors, the second Technical Meeting is dedicated to the achievements, capabilities, and future prospects of small reactors. This meeting also celebrates the 50th Anniversary of the Nuclear Power Demonstration (NPD) reactor which was the first small reactor (20 MWe) to generate electricity in Canada.

Topics of Interest

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

- Safety and Licensing
- Reactor Physics (physics code validation, bias and uncertainty, benchmarking, etc.)
- Thermalhydraulics (passive safety, heat pipes, etc.)
- Advanced Fuels (new compositions, inherently safe fuels, etc.)
- Instrumentation and Control
- Research reactors and low power critical facilities
- Education and training
- Commercial SMRs for electricity generation
- Small reactors for remote locations
- Autonomous Control and Operation
- Novel Concepts

Abstract Submission

Authors should submit an extended abstract (two to three pages) with contact information, via electronic mail, to the Technical Program Chair, Shuwei Yue, (yues@aecl.ca). Extended abstracts will be published in the Conference Proceedings (CD format).

Technical Meeting Organizers

Advisory Committee. . . . . Fred Boyd, CNS
Adriaan Bujis, McMaster University
Romney Duffey, DSM Associates
Iain Harry, CIC
Paul Labbé, DRDC
John McKenzie, SaskPower
Dan Meneley, UOIT
Eleodor Nichita, UOIT
John Root, CCNI
Benjamin Rouben, 12 & 1 Consulting
Marcel de Vos, CNSC

General Chair . . . . David Sears, AECL
Technical Program Chair . . . . .Shuwei Yue, AECL

Key Dates

Extended abstracts deadline . . . . August 31, 2012
Early-Bird registration deadline . . . . . September 15, 2012

Further Information

Additional information may be obtained by visiting http://cns-snc.ca/events/2tm/ or by contacting David Sears, General Chair, AECL, Chalk River Laboratories, Chalk River, Ontario K0J 1J0 CANADA, Tel: (613) 584-3311 ext. 44200; Email: searsd@aecl.ca.

NPD – Canada's First Power Reactor


NPT
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