CANADIAN NUCLEAR SOCIETY
bulletin
DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

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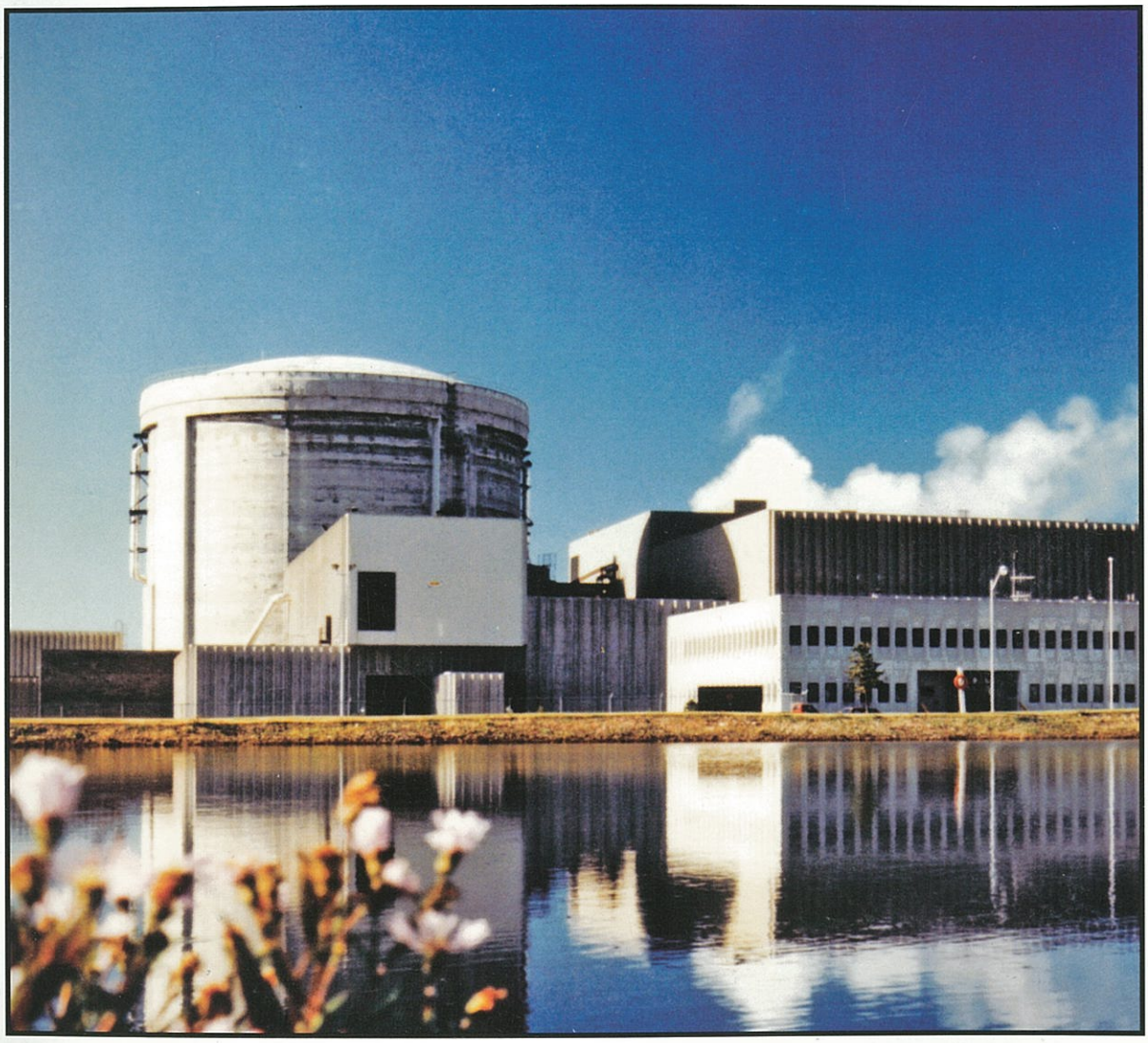

- Annual Conference
- Nuclear Achievement Awards
- CAPD Anniversary
- Pt. Lepreau Rehabilitation
- Story of ZEEP
- Developing People

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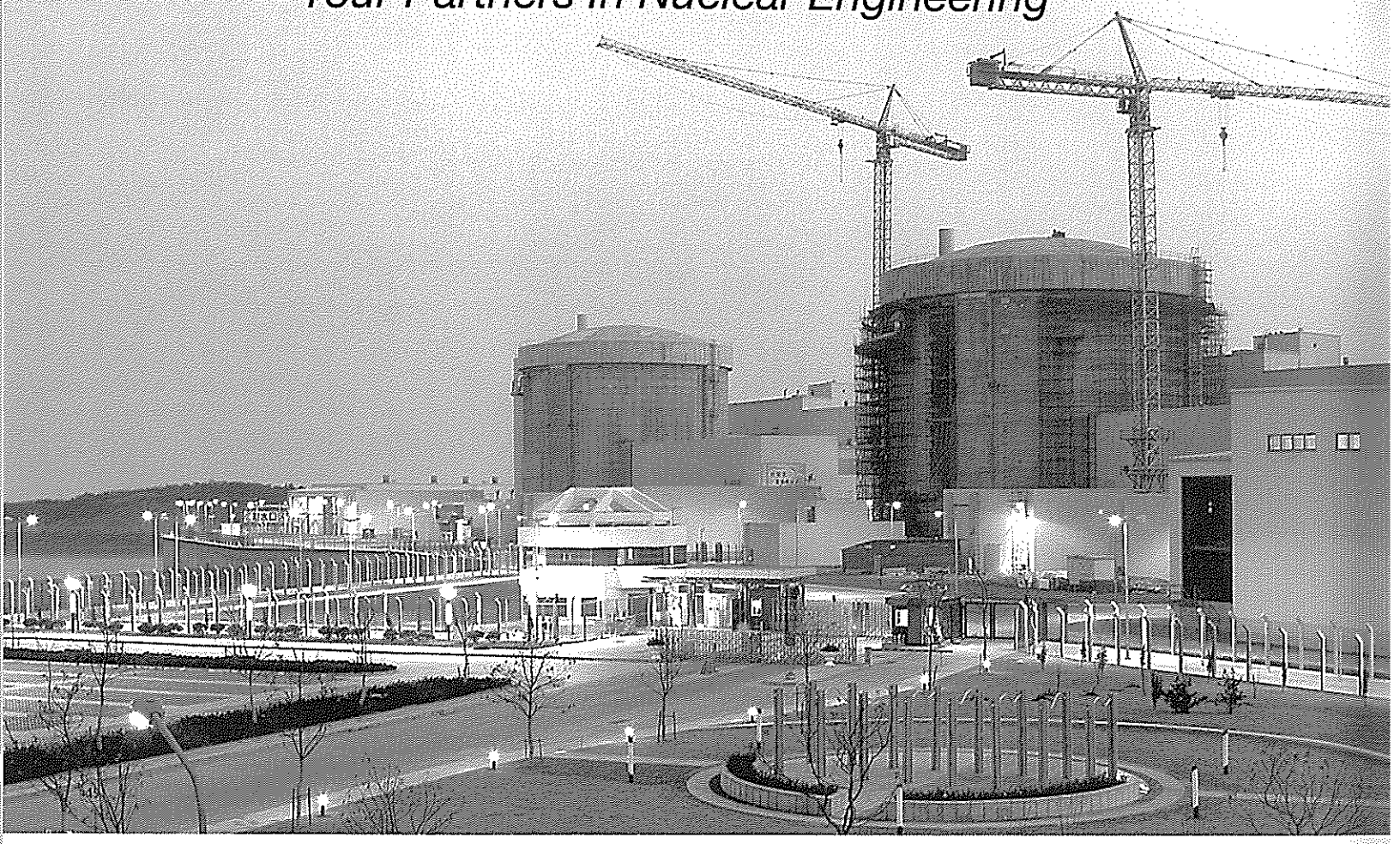

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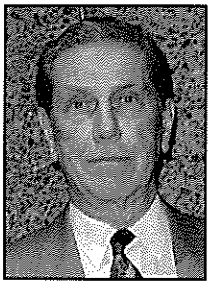
EDITORIAL

Positives and Negatives



Although this is being written almost three months after the 26th CNS Annual Conference (held in June 2005) that gathering remains prominent in our view of the Canadian nuclear program, modified by what has transpired since then.

The mood at the Conference reflected both optimism and frustration. Developments since then have been both positive and negative.

On the positive side, the New Brunswick government has approved the rehabilitation of the Point Lepreau station, despite being rebuffed by the federal government on the province's request for federal contribution under its Kyoto plan.

Ontario Power Generation, on the other hand, announced that it would not go ahead with the rehabilitation of Pickering units 2 and 3, only two months after its Chief Nuclear Officer spoke optimistically about the project at the Annual Conference.

And, at the time of writing, Bruce Power still has not received any response from the Ontario government on its proposed major investment in the rebuilding of Bruce units 1 and 2. The frustration of Bruce Power's CEO, Duncan Hawthorne, during his talk to the Annual Conference, was palpable.

In recent speeches, however, the Premier of Ontario has indicated that the Ontario government is beginning to realize that it needs nuclear power if the province is to continue to have reliable, reasonably economic electricity, especially in the face of his proposal to shut down coal-fired plants. But, he has said, the provincial government will not make any decisions until it receives the recommendation of the new Ontario Power Authority. That organization, however, seems determined to drag out their analysis interminably.

Then, there is the MAPLE project! There was not even a hint of that sad affair at the Conference and there continues to be complete silence, except for presentations to the regulator. The only positive note is the fact that AECL has (finally) made significant changes to the management and organization of the program.

To close on a positive note, the growing interest of offshore companies, as evidenced by their presence at the Annual Conference, suggests that they see a nuclear future in Canada as inevitable. Perhaps we can gain some optimism from that.

Fred Boyd

IN THIS ISSUE

This issue of the CNS Bulletin is drawn almost totally from the **26th CNS Annual Conference** held in June 2005.

It begins with a report on the Conference followed by one on the **Canadian Nuclear Achievement Awards** that were presented at the conference banquet.

Then there is a short note on another event, the **50th Anniversary of the Civilian Atomic Power Department** of what was then Canadian General Electric (now GE Canada).

A further touch of history is presented in the paper **ZEEP: Canada's First Nuclear Reactor** that Ralph Green gave at the third plenary session of the Conference. (The 60th anniversary of the startup of ZEEP is being commemorated by an exhibit at the Museum of Science and Technology in Ottawa.)

The technical papers have all been chosen from those presented at the Conference. Our choices are very subjective, being primarily based on topics judged to be of relatively wide interest (which, unfortunately, excludes many of the excellent but very specialized ones presented).

First is **Point Lepreau Refurbishment - Update 5** which is, of course, very timely. Then there are two papers related to the "people" aspect of the business. First is **Developing People for the New Nuclear Generation** that describes the approach being taken at NSS. The second is one giving a regulatory view, **Assessing Human Performance through a Model-Based Regulatory Approach.** The last paper selected is on a non-Canadian reactor, **EPR, Meeting International Safety Standards with Margins.**

There is a relatively short section on **General News** and, as has become the norm, another Obituary about one of our pioneers.

The section on **CNS News** has a mixture of items from the Annual General Meeting to a report on the attendance of one of our younger, very active members, Mark McIntyre, on his attendance at the summer 2005 session of the newly constituted World Nuclear University.

There are the inimitable words from Jeremy Whitlock in **Endpoint** and an update of the event **Calendar.**

Please note also the increased number of advertisements, a sign of the possible resurgence of nuclear power in this country.

Your comments (good or bad) are always welcomed.

Contents

~ Cover Photo ~

The cover photograph shows a familiar view of the Point Lepreau nuclear generating station in recognition of the decision to proceed with its rehabilitation.

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bulletin

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CNS provides Canadians interested in nuclear energy with a forum for technical discussion. For membership information, contact the CNS office, a member of the Council, or local branch executive. Membership fee for new members is $75 annually, $44.00 for retirees, free to qualified students.

La SNC procure aux Canadiens intéressés à l'énergie nucléaire un forum où ilf peuvent participer à des discussions de nature technique. Pour tous renseignements concerant les inscriptions, veuillez bein entrer en contact avec le bureau de la SNC, les membres du Counseil ou les responsables locaux.
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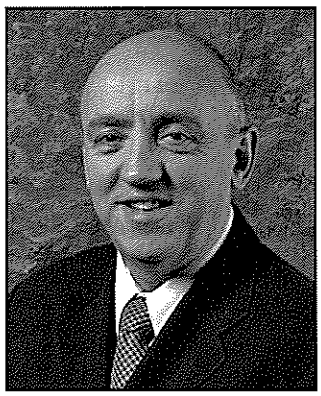
26th CNS Annual Conference

Record attendance reflects optimism but messages mixed at the 26th CNS Annual Conference

Both the progress and the uncertainty of Canada's nuclear program were the subjects of the plenary speakers at the 26th Annual Conference of the Canadian Nuclear Society held in Toronto, June 12 - 15, 2005, while the 60 technical papers presented reflected the advances in the technology.

A record 350 delegates convened at the Marriott Eaton Centre Hotel, as in the past couple of years, to hear senior representatives of the industry provide insights into the state of the nuclear power and uranium programs and to exchange developments in their particular fields. Many gathered at the pre-conference reception on the Sunday for a relaxed social evening.

Thomas Isaacs



Duncan Hawthorne

Embedded in the conference was the **29th Student Conference** sponsored by the CNS and the Canadian Nuclear Association. Twenty-nine papers were presented in four sessions. In addition *Women in Nuclear* (WIN) and the *North American branch of the Young Generation Nuclear* (NA-YGN) held special lunch hour programs on the second day.

An innovation this year saw the **W. B. Lewis** lecture being presented at the Monday luncheon. The invited lecturer was **Thomas Isaacs,** of the Lawrence Livermore National Laboratory in the USA, who spoke on *Canada's Imminent Decision on Nuclear Used Fuel Disposition.* His sub-title was *Decision-Making at the Intersection of Science, Politics and Society.*

In a fast-paced, animated presentation he noted that nuclear waste is perceived to be very different from other wastes and much more difficult to manage. The challenge, he commented, has been much more than technical. He reviewed briefly the US program leading to the choice, many years ago, of Yucca Mountain and the on-going political argument. Turning to the Canadian program he praised the Nuclear Waste Management Organization for its approach to the problem.

At the Wednesday luncheon, **Harold McFarlane,** vice-president of the American Nuclear Society, provided an overview of the state of the nuclear power program in the USA. Ten years ago, he noted, operation of nuclear plants in the USA was very poor and the prospects negative. Now, operation is very good, with most plants exceeding 90% capacity factor, and there are prospects of new plants. Public attitude has also changed, with polls showing about two thirds being favourable towards new nuclear plants.

The conference banquet, on the Tuesday evening, was devoted to presentation of the Canadian Nuclear Achievement Awards from the CNS and CNA. *(See separate article.)*

Conference chairman **David Torgerson,** senior vice-president at Atomic Energy of Canada Limited, opened the conference on the Monday morning with a few comments on the need for new electricity generation and the potential role of nuclear. He also mentioned AECL's Advanced CANDU Reactor design and the company's participation in the International Generation IV program. "The future looks very good", he said in closing.

Then **Ken Petrunik,** also an senior vice-president at AECL, opened the first plenary session, which had the theme Nuclear Operations and Directions.

Bill Schneider, recently retired from Babcock & Wilcox Canada and outgoing CNS president, spoke about the new CNS focus on operation of nuclear plants to augment the traditional emphasis on research and design. He invited attendees to participate in the special student panel session on the Wednesday afternoon.

The opening plenary speaker was **Duncan Hawthorne,** CEO of Bruce Power, who gave one of his typically frank assessments of the Canadian nuclear power program. "Big decisions [about nuclear power projects] must be made within the next few months", he asserted. "If they go the wrong way they will be irreversible", he warned, adding that he did not know which direction they will take. Ontario needs electricity but the public [and therefore politicians] is not convinced about nuclear, he added. "I am not particularly upbeat", he acknowledged.

Almost as an aside he commented that the lease of the Bruce stations expires in 2018. If there is no new nuclear committed well before then, that will be the end of the Canadian nuclear industry, he cautioned.

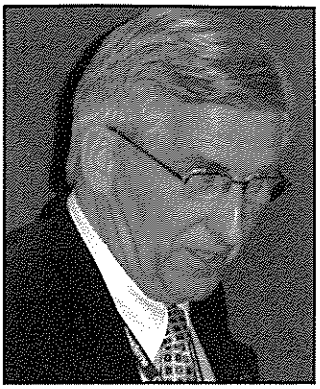
Hawthorne then turned to a review of Bruce Power. The proposal to rehabilitate Bruce A units 1 and 2 and to

improve the Bruce B units has been before the Ontario cabinet for months. A decision is needed very soon, he stated. The delay, he suggested, is because the nuclear industry does not have any friends. "Everyone wants us at the party", he quipped, "but no one wants to dance with us."

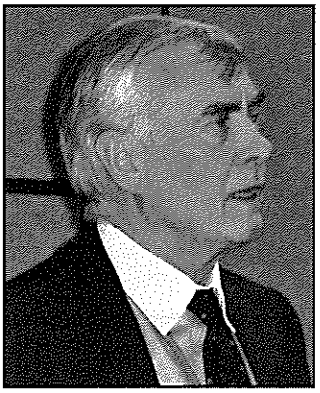
For the Canadian nuclear program to proceed, he stated, the following are needed:

- a clear regulatory framework
- tightly defined and executed projects
- fixed price contracts
- world class management

He closed with a quote from James Ritch of the World Nuclear Association, "In this century ahead, nuclear energy will be nothing less than indispensable if we are to meet the greatest challenge humankind has ever faced". *(Unfortunately there was no allowance for questions at the opening plenary session.)*



Rod White



Arthur Carty

Next was **Pierre Charlebois,** chief nuclear officer at Ontario Power Generation. He began by noting that in the previous 12 months OPG has acquired a new Board, a new president, and a new environment. Commenting on the regulated electricity market in Ontario he noted that OPG receives $49.50 / MwHr while the market average for the first half of 2005 was $57.00 / MwHr.

The refurbishment of Pickering unit 1 is 90 % complete and the unit is on target to be on line in the fall of 2005. *(Ed. Note: CNSC granted OPG approval to begin startup commissioning at its July hearing.)* He reported that plans are proceeding, including the preparation of the business case, for the rehabilitation of Pickering units 2 and 3. *(OPG announced in August the project would not go ahead.)*

The operational target is "boring" good performance, he commented. Other objectives are: development of succession plans; a program for intern training; focus on "value for money". OPG's workforce has an average age of 45, he noted, and. although this is lower than a few years ago, it still means there will be a significant number of retirements over the next ten years. To deal with the problem OPG has increased hiring and is improving knowledge transfer.

In a quick overview of performance Charlebois noted that Darlington was running very well and is working towards a 36-month outage cycle. The most significant challenge, he said, is the observed thinning of feeders. Plans for their replacement are being accelerated. For Pickering B the aim is to return to high performance. As generation increases, he noted, the unit production cost decreases. " 'New build' is in the distant future", he commented in closing.

After the break **Marc Doyon** of Hydro Québec provided an update on the plans to refurbish Gentilly 2. A decision by the Board of HQ is expected in 2006.. If the project is approved it would take place over 2010 - 2011.

The program would include: retubing the reactor; refurbishing the turbine generator and condenser; upgrading the emergency core cooling system and the emergency power system; and, replacing the control computers. The estimated cost is $1.2 B. In anticipation of approval by the HQ Board an environmental assessment has been submitted to the Canadian Nuclear Safety Commission and Quebec authorities.

Rod White, just retired vice-president at New Brunswick Power, provided a similar update on the plans for refurbishing the Point Lepreau station. He preceded that with a quick review of the recent restructuring of NB Power into a holding company and five operating ones: Nuclear: Generation; Coal; Distribution; Transmission.

At Point Lepreau the number of licensed operators has been increased and improvements made in management processes. During an outage in the spring of 2005 seven feeders were replaced, although only one was found to have cracks.

(On July 29, 2005, New Brunswick premier Bernard Lord announced that the refurbishment of Point Lepreau would proceed with AECL as the prime contractor.) (See also the paper on Point Lepreau Refurbishment - Update 5 in this issue of the CNS Bulletin.)

Moving away from reactors, **George Assie,** senior vice-president at Cameco Corporation, provided an overview of the Canadian uranium industry, beginning with a quick historical review. Despite production being less than demand the price of uranium remained low over the past decade because of the supply of former weapons material from Russia. There is a predicted need for 1.6 million more pounds over the next two decades then current production will provide.

He outlined some of the activity in Saskatchewan, such as the expansion of the McArthur River mine; development of the rich Cigar Lake deposit and other projects. Cameco and Cogema (Areva) are both expanding their exploration and a number of junior mining companies are becoming active. He warned, though, that the long lead-time between finding a deposit and developing a mine presents a significant risk of shortfall in the future.

The second plenary session, held on the Tuesday afternoon, focussed on *New Directions in Science and Technology.*

Arthur Carty, National Science Advisor (and former president of the National Research Council) led off with a talk he titled *Future Prospects for Canadian Infrastructure*

in Support of Science and Industry. He and his office are taking a long-term view of science and technology in Canada, including innovation and commercialization. There is now better collaboration between the federal departments involved in science and technology, he said.

A particular interest is the establishment of major infrastructures, projects too large for any one institution, such as the Sudbury Neutrino Observatory. It is necessary, he said, to;

- set priorities for achieving Canadian goals
- identify sources of funds
- create effective management (for operation as well as construction)

An accountable and transparent process is needed, he emphasized.

He mentioned that the National Research Council is studying three options for a new Canadian Neutron Facility

In closing he noted that his office issued last spring a discussion paper: *A Framework for the Evaluation, Funding, and Oversight of Canadian Major Science Investments.* The final version will be prepared in the fall of 2005.

Ray Ganther, of Areva Framatome ANP, spoke on *The EPR for North America* in which he extolled the virtues of his company's new nuclear power plant design, the EPR. The design is an evolution based on 77 operating pressurized water reactors (PWR) in France and Germany. The objectives, which he said had all been attained, were to: reduce operating cost; reduce core damage frequency; and, accommodate severe accidents; all to improve the confidence of investors, operators and the public. Safety features include double wall containment and four safety trains. The EPR is designed to load-follow, he commented.

Ganther noted that the EPR is now being built in Finland and is being reviewed by the United States Nuclear Regulatory Commission for design certification in the USA.

That mildly promotional presentation was followed by a somewhat similar one by **Jerry Hopwood,** of Atomic Energy of Canada Limited whose talk was titled *ACR 1000 - Optimized Plant for Utility Requirements.*

He began by emphasizing that the ACR 1000 is "customer oriented". While maintaining many CANDU features, notably fuel channels, heavy water moderator and on-power fuelling, the design has many innovations. Slightly enriched uranium is used which offers improved core characteristics and permits the use of light water as the coolant. There is an emphasis on passive safety.

He noted that the Canadian Nuclear Safety Commission had issued a "screening report" on the predecessor ACR 700 design and the Nuclear Safety Commission of China is reviewing the basic ACR 1000. AECL is ready to start the detailed design, he said, and an ACR 1000 could be in service by 2015.

Pat Tighe, also of AECL but also representing CANDU Owners Group, titled his presentation *CANDU Refurbishment - Managing the Life Cycle.* He began by outlining the economic and environmental arguments for refurbishment.

He went on to outline;

- the benefits of extended plant life
- the outlook for refurbishments
- the life management and refurbishment program
- preparations for retubing

Several CANDU plants are considering refurbishment, he noted, such as Point Lepreau, Wolsong 1, Gentilly 2. with the intent of extending their life. A major aspect is the retubing of the reactors. AECL has developed a number of tools and processes for doing that task efficiently, he commented.

In response to a question he stated studies show that the resources needed for the many refurbishment projects being considered will be available.

In his presentation *A New Epoch for Back End Fuel Cycle in Korea,* **M.J. Song,** of Korea Hydro and Nuclear Power, commented that the success of the nuclear power programs in Korea, as in many countries, depends on a solution for nuclear waste. Korea is still looking for a final waste disposal site. A repository for low and intermediate waste is underway for completion in 2008.

I. Rotaru, from AREN, Romania, spoke on, *Nuclear Power in Romania - Present and Future.*

He noted that Romania is self sufficient in uranium and heavy water and has the national infrastructure needed for a nuclear power program.

Unit 1 at Cernavoda is operating well and unit 2 is expected to be on line in 2006. Discussion are underway for unit 3.

Development of a Licensing Basis for Future Power Reactors in Canada, was the title of the presentation by **Greg Rzentkowski,** of the Canadian Nuclear Safety Commission.

He commented at the beginning that a draft regulatory document had been issued for comment in early 2005. The objective is to have a formal, comprehensive set of regulatory requirements that are more in line with international practice. The underlying approach, he said, is to have the requirements "risk informed".

The safety goal is to ensure that nuclear power plants do not present a significant risk to people or the environment. Among the objectives are:

- very low frequency of core damage
- mitigation of accidents
- keeping radiation exposures as low as reasonably achievable (ALARA)

The recent standard issued by the International Atomic Energy Agency, NS-R-1, has been a major guide, augmented by Canadian experience and international trends.

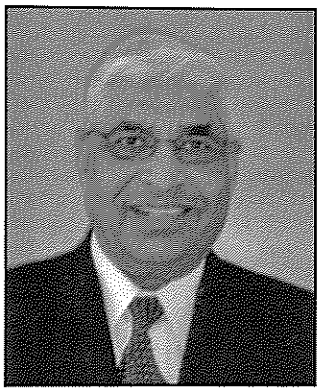
To a question he stated that the CNSC will be requiring analysis of severe accidents (beyond design basis) and admitted that is was partially because "everyone else is doing it".

The third and final plenary session took place on the Wednesday morning, with the theme *People and Technology for Operations.*

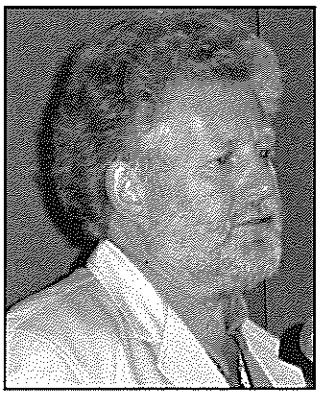
Leading off the presentations, **Kevin Rutledge**, president of Nuclear Safety Solutions, dealt with the topic *Developing People for the New Nuclear Generation.* "The problem is people", he stated at the beginning.

Nuclear appears to be on the verge of turning a corner, he commented, yet one third of current employees will be eligible to retire in the next few years. We need a sustainable supply of people, he argued, which involves: recruitment; training; knowledge transfer; and development. An international response may be needed, he commented. A particular shortage exists now, he asserted, of people with the combination of technical knowledge, communication skills, and management ability. He suggested that the CNS and CNA present workshops for training and upgrading current staff.

Referring to the planned refurbishment of Canadian nuclear plants he noted the growing and possibly critical shortage of skilled trades. "With the size of the pie growing", he quipped, "we need enough bakers".



Mohan Mathur



Colin Seymour

Mohan Mathur, head of the University Network for Excellence in Nuclear Engineering (UNENE), spoke of the role of his organization and the development in general of nuclear education in Canada.

UNENE, he noted , is currently primarily aimed at providing graduate level training for professional in the Canadian nuclear industry. It was incorporated in 2002 with the objectives of:

- enhancing the supply of qualified people
- strengthening university research and development
- facilitating consultation of the public, government and industry with university based expertise.

UNENE is supported by the federal Natural Science and Engineering Research Council (NSERC) but is industry driven, he said.

Currently UNENE offers four masters level programs:

- nuclear power systems and operations
- reactor physics
- reactor safety design
- reactor thermalhydraulics

Further programs are being developed.

David Moore, of Babcock & Wilcox Canada, spoke on *Uncertainty and Risk from a Suppliers Perspective.*

We are just one accident away from all going out of business, he stated. The market system for electricity has resulted in pressure to cut costs and reduce risks. For suppliers this has translated into: low prices; aggressive schedules; stringent guarantees; and a reliable, easily maintained product. It is necessary to identify the risks as early as possible in any project, he commented in closing.

After the break there was a shift in focus.

Colin Seymour, of McMaster University, led off with a discussion he titled *Linear No-Threshold (LNT Model - Myth or Reality?* referring to the currently accepted hypothesis that any amount of radiation has a negative effect regardless how small.

Science, he began, is a combination of facts and interpretations. He noted that the LNT model was based primarily on observations of the survivors of Hiroshima and Nagasaki. It also fits target theory, he noted. Unfortunately, a non-linear theory is complex, he commented, and referred to the 19th century French mathematician Henri Poincaré who showed that non-linear systems could sometimes behave in a chaotic manner. He also noted Paracelsus, a physician of the 15th century, who observed that a small dose of something that makes a person ill when taken in large amounts can cure them.

He concluded by suggesting that the LNT be used as an optimization tool for radiation protection *(which was the original intention decades ago).* To a question he stated that his concluding remarks did not imply that he supported the current approach of the International Commission on Radiological Protection.

Next was a look back in history by **Ralph Green**, a former vice-president of AECL, who spoke about *ZEEP: Canada's First Nuclear Reactor.*

He began by noting the celebrations this year titled "100 years of physics" to acknowledge the three concept-changing papers by Albert Einstein in 1905. Fission was formally recorded in early 1939 just months before the outbreak of the Second World War. British and European scientists came to Canada in 1942 to participate, with Canadians, in the Montreal Laboratory set up under an agreement between Canada, the UK and USA. By 1944 they had progressed sufficiently to support a decision to build a heavy water moderated reactor [initially for the production of plutonium], which would result in NRX. John Cockcroft, the director of the Montreal Laboratory, desired an experiment to test the theories that had been rapidly developed. That led to the decision to build a 1 watt reactor, which was called ZEEP (zero energy experimental pile). It went critical September 5, 1945, the first reactor outside the USA.

ZEEP was shutdown in 1947 but restarted in 1950 with some additional shielding to permit operation up to 50 watts and used to confirm the design of NRU. Shutdown

again in 1957, additional shielding was installed and ZEEP was operated until 1968 testing fuel designs for CANDU.

Next was **David Torgerson,** executive vice-president at AECL, whose subject was *R & D for Operational Excellence.*

He noted that although AECL was pursuing research and development in several areas in support of CANDU he would concentrate on those specifically aimed at operations.. Under the broad subject of "life management" he noted work on "smart CANDU" modules:

- CAMLS - annunciation, message, list system
- ChemAND - plant chemistry
- ThermAND - heat balance
- MIMC - maintenance information management.

There are also programs on materials, such as new alloys for pressure tubes, he noted.

He showed a short video of the feeder flow test facility used to explore the mechanism of feeder thinning and cracking.

One of the projects related to safety is targeted at a CNSC "generic safety issue" on the interaction of molten fuel with the heavy water of the moderator. In all of the work there is close collaboration with nuclear plant operators, he emphasized.

Scenes from The Conference

The Greening of Nuclear was the title chosen by **Murray Elston,** president of the Canadian Nuclear Association for his presentation, the last one of the plenary sessions.

He noted recent supportive statements of several people, who had been identified as "environmentalists", as evidence that nuclear energy is beginning to be recognized as an essential energy source that does not emit greenhouse gases.

To a question he commented that the CNA's new TV advertising will be aimed at reclaiming the word "nuclear".

The sixty plus **Technical Papers** were presented in 11 sessions spread over the three days. The subject titles of the sessions give an insight into the wide scope of the papers.

- Risk Assessment (2)
- Control Room Operations
- Safety Analysis (2)
- Core Physics
- Plant refurbishment
- Education and Communication
- Materials Performance
- Licensing and New Reactors
- Instrumentation and Control

Similarly, the embedded **Student Conference** had four sessions, divided into the following groupings:

- Nuclear Waste Management and Radioisotope Applications in Environmental Engineering
- Radiation Applications and Nuclear Power Reactors
- Advanced Nuclear Reactors and Nuclear Reactor Fuel
- Applications of Radiation and Radioisotopes

A special session was held on the Monday afternoon on **Public Interaction: Challenges, Strategies and Needs.**

The conference was organized and presented by a large committee of volunteers. David Torgerson was the honorary chair with John Luxat (who became CNS president at the AGM during the conference) as the executive chair. Ed Hinchley, Ken Smith, and Richard Fluke organized the plenary sessions while Krish Krishnan chaired the technical program committee. The embedded student conference was chaired by Hugues Bonin. Ian Wilson obtained the sponsors

Other members included: Fred Boyd; Jasia De Groote; Prabhu Kundurpi; Dan Meneley; Eleodor Nichita; Yuksel Parlatan; Jad Popovic; Ben Rouben; Eric Williams.

Denise Rouben looked after the hotel arrangements, general administration and registration. Helping at the registration desk were; Melissa Boyd; Isabelle Beaulieu; Kathy Davies; and Sanela Turkanovic.

A CD with the Proceedings of the conference, including all of the technical papers and the PowerPoint presentations of the plenary speakers, is available from the CNS office.

There were displays by: AECL; Areva; Babcock & Wilcox Canada; Ian Martin Ltd.; Korea Electric Power Research Institute; Kinetrics; NLI Canada; UOIT; Imaging and Sensing Technology; IAEA.

Conference Sponsors

The support through sponsorship by many companies associated with the Canadian nuclear program enables the organizers to enhance the program and offer the luncheons, banquet, coffee breaks and other features that make CNS conferences special. The organizers and Society in general thank the following sponsors of the 26th CNS Annual Conference.

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Canadian Nuclear Achievement Awards

As has been the practice the past few years, the Canadian Nuclear Achievement Awards, sponsored jointly by the Canadian Nuclear Association and the Canadian Nuclear Society, were presented at the banquet of the 26th CNS Annual Conference in Toronto on June 14, 2005.

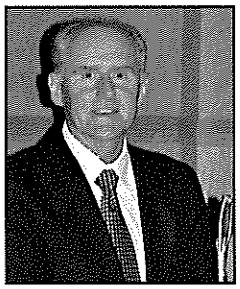
Prior to the official ceremony, Murray Elston, CNA president, made a presentation of the **CNA International Award** to **Mr. Oh-Cheol Kwon,** currently senior vice-president of Korea Hydro & Nuclear Power Company. Mr. Kwon has been involved with the CANDU units in Korea since 1980 when he was involved in the construction of Wolsong 1. In 1993, he became Deputy Manager of Wolsong and, in 1999, Director of the Wolsong site. He was appointed to his present position in 2002

Following are the Canadian Nuclear Achievement Awards presented, with their criteria, the recipients and their citations.

Ian McRae Award of Merit

Purpose of the Award

To honour an individual for outstanding contributions, other than scientific, to nuclear energy in Canada.



Dr. Gary Kugler

Citation

Dr. Kugler has been a key contributor to AECL's successful international commercial CANDU reactor activities for more than 20 years. In over three decades at AECL, he worked in a variety of technical, project management, marketing, commercial, and senior management areas. Gary became Vice President, Commercial Operations in 1995 and was appointed Senior Vice President, Nuclear Products and Services in 2001. He retired in 2004 and was appointed to the OPG Board of Directors.

Dr. Kugler was manager of Canadian operations for AECL's Embalse CANDU project in Argentina, and later led AECL's team that secured the Wolsong 2, 3, and 4 CANDU sales in South Korea. These multi-party contracts involved simultaneous negotiation and interface with several Korean entities – the client, the government, research institutes, the nuclear regulatory agency – as well as Korean and Canadian engineering companies and equipment suppliers.

More recently, Dr. Kugler held executive responsibility for the negotiations with Chinese agencies for the Qinshan CANDU project and with Romania for completion of Cernavoda 2.

Gary Kugler's skill, determination, and tenacity have played a major role in the offshore success of the CANDU product, with benefits that extend to the entire Canadian nuclear industry through multi-million-dollar supplier and engineering contracts, and support for advanced R&D of the technology.

Outstanding-Contribution Award

Purpose of the Award

To recognize Canadian-based individuals, organizations or parts of organizations that have made significant contributions in the nuclear field, either technical or non-technical. There are two categories of the award, one for individuals and another for organizations or parts of organizations.

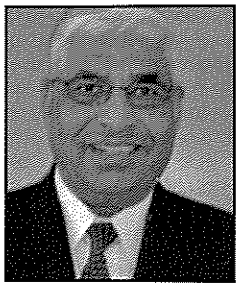
Five awards were granted.

Dr. George Bereznai

George Bereznai is currently Dean of the School of Energy Systems and Nuclear Science at the University of Ontario Institute of Technology (UOIT). He is also a member of the Board of Directors of the University Network of Excellence in Nuclear Engineering (UNENE). George graduated in Electrical Engineering from the University of Adelaide in South Australia in 1967. After receiving a MEng and a PhD in Electrical Engineering from McMaster University, George joined Ontario Hydro in 1972 at its nuclear training centre. He rose to Senior Training Officer, and in 1980 moved to the Simulator Services Department, becoming Manager in 1982, eventually overseeing 70 persons and the operation of five training simulators.

From 1987 to 1990, George took on a temporary posting with the New Business Ventures Division as Business Development Manager for Eastern Europe, where he opened Ontario Hydro's first overseas office. In 1995, Dr. Bereznai took on a five-year appointment with AECL, as the Chair of Nuclear Engineering at Chulalongkorn University in Bangkok, Thailand. He developed and implemented a nuclear engineering curriculum comprising bachelor, master's, and doctorate programs, delivering courses on CANDU systems, operations, and control. He also taught similar courses in China, Indonesia, Vietnam, and the Philippines. In 2001, Dr. Bereznai became the founding Professor and Dean of Energy Systems and Nuclear Science at the UOIT. Always a respected member of the Canadian

nuclear community, George has made a considerable contribution educating nuclear scientists and engineers in Canada and abroad.



Dr. R. Mohan Mathur

Dr. Mohan Mathur has contributed significantly to the engineering profession in Canada, to the training processes for nuclear staff at Ontario Power Generation and Bruce Power, and to the creation of the University Network of Excellence in Nuclear Engineering (UNENE).

Dr. Mathur received his doctorate in Electrical Power Engineering from the University of Leeds. He immigrated to Canada in 1969, starting his academic career at the University of Manitoba. He served as Professor and Head, Department of Electrical and Computer Engineering, at U of M before becoming Professor and Dean, Faculty of Engineering Science at the University of Western Ontario in 1987. In 1999 Dr. Mathur became the Vice President, Nuclear Training Support and Services Division of Ontario Power Generation. Dr. Mathur served on the Canadian Engineering Accreditation Board from 1992 to 2001. He has also served on the Board of Governors, University of Western Ontario, and the Board of Directors of Ontario Hydro, where he was Vice Chair from 1992 to 1996.

With this background in academia and nuclear industry training and an understanding of the impending peak in requirements for staff in nuclear science and engineering, Dr. Mathur, with his contacts in academia and industry, developed the vision of UNENE. His vision and persistence have resulted in a viable collaboration that funds six senior Industry Research Chairs and is drawing graduate and post-graduate university students to pursue a career in the nuclear industry. Under Dr. Mathur's guidance as founding President, UNENE is contributing to the long-term viability of the CANDU industry through provision of trained personnel and the undertaking of pertinent research and development.

Dr. Wladimir Paskievici

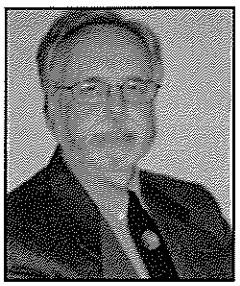
Wladimir Paskievici, Emeritus Professor, CNS pioneer and one of the founders of the Institut de génie nucléaire at École Polytechnique, has served for four decades as a gifted professor and internationally recognized nuclear safety consultant.

From 1958 to 1990, Dr. Paskievici taught at École Polytechnique and from 1981 to 1982 as Director of the Institut de génie nucléaire. From 1982 to 1990, he served as Vice-Dean of Graduate Studies at École Polytechnique.

While fulfilling his very broad academic responsibilities, Dr. Paskievici served as a nuclear-safety and reactor-control consultant to the Atomic Energy Control Board, Hydro-Québec, Ontario Hydro, Atomic Energy of Canada Limited, Environment Canada, Justice Canada, and Energy, Mines and Resources Canada. He was a key member of the original Reactor Safety Advisory Committee of the AECB and, later, a member of the Advisory Committee on Reactor Safety. In 1981, he joined a team of Canadian professors established by AECL to prepare recommendations on how Canadian universities could assist Mexican universities in developing nuclear engineering programs.

He produced more than fifty technical reports and scientific studies and a series of École Polytechnique publications on atomic physics, nuclear-resonance theory, the dynamics of reactor control, and reactor safety.

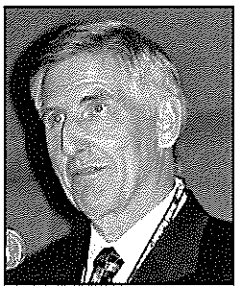
(Dr. Paskievici was unable to be present.)



Mr. John Roberts

John Roberts, Design Authority for Chemistry at Bruce Power, has served the CANDU industry in Canada and abroad for 35 years by demanding chemistry excellence in the operation of plants. John arrived in Canada in 1977 with a first class honours degree in chemistry and experience as assistant chemist at the Trawsfynydd Nuclear Power Station in Wales. At Ontario Hydro he gained experience in process chemistry, metallurgy and chemical decontamination, before becoming station chemist at Bruce B. In the early 1990s, he served nearly two years at the Cernavoda Nuclear Station establishing chemistry laboratory programs and training Romanian personnel. With the exception of a short time at the Pickering Nuclear Generating Station, he remained at Bruce in various chemistry-related positions undertaking assignments to resolve various operational issues. He is now accountable for oversight of the chemistry programs at Bruce Power.

John is a plant chemist with passion. He has always been ahead of his time in realizing that good chemistry is the key to longevity. He has shown an adamant commitment to excellence and a rigorous adherence to standards and procedures that stand up against the demands of production. He has championed collaborative tests at Bruce to define operational parameters to the benefit of the whole CANDU community. Through his numerous industry contacts, his participation in industry forums, numerous papers, participation in the CANDU chemistry course and workshops, his training courses at Bruce, and his contributions to Cernavoda and Cirene, he has personified the benefits of excellent chemistry at nuclear power plants.



Mr. Rod White

Rod White is a well-recognized and respected member of the Canadian nuclear community. He has thirty-eight years of experience in the electricity generation sector, of which nineteen years were related directly to nuclear power.

Rod White has made significant

contributions towards the success of Point Lepreau. He was maintenance superintendent during construction and early operation, where he established the maintenance programs and associated infrastructure. Later, as Vice President – Nuclear, he contributed to station performance improvement, restoration of regulatory confidence, and preparation for station refurbishment. The results of his efforts have increased confidence in nuclear power in New Brunswick as a cost-effective, reliable and environmentally sound means of electricity generation .

Rod is admired for his leadership, inspiration, communication skills, keen focus, judgement, and genuine concern for people. Rod has been a strong supporter of nuclear plant refurbishment and life extension. He has recognized that success in these large projects is directly linked to the level of preparedness of the engineering, planning, and procurement. This will serve Point Lepreau well when project approval is finally achieved.

All through his career Rod White has shown unwavering support and devotion to nuclear-power generation in New Brunswick, in Canada and internationally. He has been a strong advocate of information exchange and co-operation within the industry

Education & Communication Award

Purpose of the Award:

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

Three awards were granted

Dr. Douglas R. Boreham

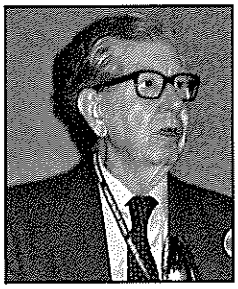
Doug Boreham graduated in Honours Biology from Laurentian University and completed his PhD at the University of Ottawa in 1990. Following ten years of innovative and productive research in low-dose radiation biology at Chalk River Laboratories, he left for a position as Assistant Professor at McMaster University in Medical Physics and Applied Radiation Sciences. In 2005 he was awarded an NSERC Industrial Research Chair.

Professor Boreham has developed a novel and successful teaching program in radiation sciences. His program progresses from radiation physics and chemistry, to biology, industrial uses, radiation protection, medical physics, and uses of radiation in diagnostics and treatment. His teaching style is innovative and inspired.

Dr. Boreham's courses are very popular. The students gave him the Student Union Award, and the University gave him the President's Award for Overall Excellence in Instruction. Doug's communication reaches far beyond the University to high school students, teachers, journalists and scientists. He was a mentor to many students attending the Deep River Science Academy.

He accepts many invitations to give scientific and public-awareness lectures. The list is extensive and attests to the wide appreciation of his ability to communicate the facts and implications of the radiation sciences to very diverse audiences. Many conference organizers recruit Dr. Boreham for review seminars in radiation biology for scientists with different backgrounds.

(Dr. Boreham was unable to be present.)



Mr. J.A.L. (Archie) Robertson

Archie Robertson has been a persistent monitor of the media's treatment of nuclear issues. He has frequently challenged the CBC, the Ottawa Citizen and other newspapers on their anti-nuclear reports and editorials. He has made numerous contributions to the CNS Bulletin, and has made good use of the internet by providing significant, thoughtful contributions on nuclear issues for public access on his personal web site. He was a strong critic of the Seaborn Panel's recommendations for the disposal of used nuclear fuel. More recently, he has reviewed the information posted by the Nuclear Waste Management Organization on its web site, and has to date contributed 19 submissions.

He retired from AECL in 1985 after a long and distinguished career in metallurgy. He was made a Fellow of the Royal Society of Canada in 1981. He was awarded the W.B. Lewis Medal in 1987, the W.J. Kroll Zirconium Medal in 1993, and the Queen's Golden Jubilee Medal in 2004. Archie is a stalwart member of the Canadian Nuclear Society Chalk River Branch. In all his contributions he demonstrates objectivity, understanding of the subject, and ideas that resonate with those of many CNS members.

Mr. Jaroslav Franta

Jaroslav Franta has for many years been a fervent communicator on the benefits of nuclear energy. As the bilingual webmaster of the Québec Branch of the Canadian Nuclear Society, he posts important educational information related to the nuclear scene, including much useful data on the history of nuclear science and technology in Québec.

Jaroslav regularly writes to newspapers to rectify incorrect or biased published information. He makes keen use of the McMaster internet discussion forum on nuclear matters, providing information and views on all science and nuclear-power matters.

As a regular speaker in schools Jaroslav has developed a hands-on educational kit for students, containing uranium ore, cloud chambers and other objects, which he uses in his speaking engagements and workshops.

Jaroslav has contributed to a CNS Québec Branch brief to the Provincial Government on the proposed refurbishment of Gentilly-2 and the expansion of its dry-storage area. He also contributed to another brief that proposed a study for a new nuclear generating station in the Province.

Jaroslav is a role model for communicating the value of science and nuclear technology to both the public and the educational community.

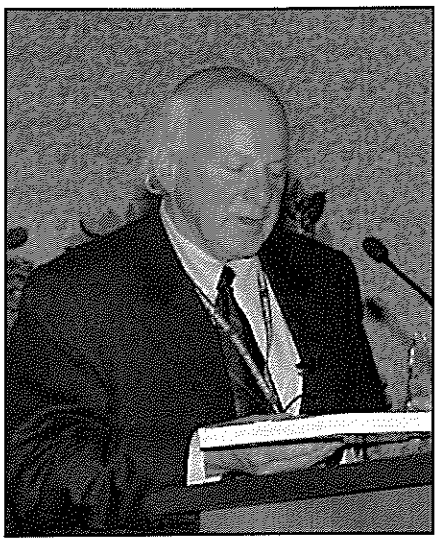
(Mr. Franta was unable to be present.)

John S. Hewitt Team Achievement Award

Purpose of the Award:

The Award aims at recognizing the recipients for "outstanding team achievements in the introduction or implementation of new concepts or the attainment of difficult goals in the nuclear field in Canada".

Two awards were presented.



Ed Price, chair of the CNA/CNS Honours and Awards committee for 2004 and 2005.

AECL Finned Strainer

The development of the finned strainer by the Atomic Energy Canada Limited team enhances safety at CANDU and other nuclear plants. It removes debris of all sizes from recirculated coolant following a loss-of-coolant accident. It is a compact design with a very large surface area, which can be backfitted into limited available space. The team at AECL consisted of David Rhodes, Ailsa Eyvindson, Daryl Kalenchuk, Nigel Fisher, Jim McGregor, Gord Brown, Les Pratt, Micky Gutzman, Liguo Sun and Binh-Le Ly.

This technology has been applied under a wide variety of plant configurations and conditions. To date, five CANDU nuclear power stations in Canada and two outside Canada in Romania and Argentina have been equipped with the new strainers. AECL is adapting its finned strainer for use in Electricité de France's nuclear stations.

Satisfactory implementation of this strainer in each station requires close coordination with utility staff. The finned-strainer team is strongly commended for their ability to adapt the design to specific needs, and for their dedication to complete the projects to the demanding schedules.

The International Tunnel Sealing Experiment

The Tunnel Sealing Experiment (TSX) was the first in situ test and demonstration of full-scale repository seal components. The TSX was conceived and implemented by AECL's Waste Technology Division, in particular those at the Underground Research Laboratory (URL) who, in conjunction with international partners (JNC, ANDRA, and the USDOE), saw it successfully through its planning, construction, operation and decommissioning stages.

The TSX was constructed within the URL in a full-scale (4.2-m-wide by 3.5-m-high) tunnel, commencing in 1997. It was operated successfully for more than 5 years under the applied conditions of high groundwater pressure (4 MPa) and elevated temperature (65∞C). The facility was decommissioned in 2004.

The success of the TSX required the efforts of a multidisciplinary and multinational team of engineers, scientists and technicians. In order to achieve such success, it was necessary to overcome a wide variety of technical challenges associated with a large-scale prototype simulation. With the successful construction and operation of the TSX, the technical viability of constructing tunnel seals in a repository environment was demonstrated, thereby building confidence in the long-term safety of nuclear fuel disposal in a deep geologic repository.

R.E. Jervis Award

Purpose of the Award

The Award recognizes excellence in research and development carried out by a full time graduate student in nuclear engineering or related fields.

Dr. Laura-lee Innes (Brown)

Dr. Laura-lee Innes (Brown) is awarded the R.E. Jervis Award for her research into the use of polymer-based composites as potential container materials to store radioactive wastes and used nuclear fuel for many centuries.

Laura-lee used neutron activation analysis to measure the parameters of the diffusion of water and acidic solutions through polymers at various temperatures. Polymers, either dry or immersed in water or acidic solutions, were then exposed to the radiation environment of the SLOWPOKE-2 reactor. They were then evaluated by several mechanical and chemical testing methods. The semi-aromatic Nylon 6,6 co-polymer was found to be the most suitable container material among those investigated in this research.

Dr. Laura-lee Innes (Brown) recently completed her PhD at the Royal Military College in Kingston under the supervision of Professor Hugues Bonin and Professor Van Tam Bui.

(Dr. Innes (Brown) was unable to be present.)

2004 - 2005 CNS/CNA Honours and Awards Committee

Ed Price, Chairman; Brian MacTavish; Hugues Bonin; Ken Smith; Colin Hunt; Greg Evans; Jerry Cuttler; Ed Hinchley; Paul Fehrenbach; Ben Rouben; Jeremy Whitlock;. Jon Jennekens; David P. Jackson; Fred Boyd; Paul Thompson; John Luxat. **Logistical Support:** Denise Rouben.

Canadian Nuclear Society
Société Nucléaire Canadienne

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Telephone: 416-977-7620 Fax: 416-977-8131 E-mail/: cns-snc@on.aibn.com web: www.cns-snc.ca

The Canadian Nuclear Society Announces the 7th International Conference and Exhibition on CANDU Maintenance November 20 – 22, 2005 at the Holiday Inn on King Hotel, Toronto, Ontario Conference Theme: Maintain the Fleet ~ Maximize Performance Honorary Chairman: John Coleby, OPG Senior VP Pickering "A"

The Canadian Nuclear Society has proudly supported CANDU science and technology for over 25 years. Heavy water moderated pressure-tube reactors are present in seven countries. The industry currently has 37 operating commercial units. In addition, there are 7 new units under construction and 3 in restart/refurbishment programs. It is a dynamic industry filled with countless challenges and successes. Change is the norm and keeping pace with research, operating experience and technological advances can be difficult. The strength of the CANDU industry is through the cooperation, mutual assistance and the exchange of information amongst its generators and service providers. This is especially true when trying to understand and resolve destiny issues as well as the rehabilitation activities necessary to extend plant life. Effective and efficient repair, replacement and refurbishment campaigns are essential and critical to the viability of all CANDU's. In this regard, the Canadian Nuclear Society offers a unique opportunity for individuals to find out the latest news on evolving inspection and maintenance techniques, strategies and trends at its 7th International Conference and Exhibition on CANDU Maintenance.

The International Conference and Exhibition on CANDU Maintenance continues to be a successful event. In recent years, the conference has attracted over 300 attendees; approximately 10% are from nations other than Canada. Corporate Sponsors include AECL, OPG, GE Canada, B&W, Bruce Power, RCM Technologies, ES Fox, Canatom, Framatome, Hydro Québec, NB Power, Nuclear Logistics and North American Power Partners.

The conference format includes a Sunday evening cocktail reception, two full course lunches and a very popular reception and dinner banquet on Monday evening. The banquet is capped off with an entertaining guest speaker from outside the nuclear industry and it tends to be one of the more memorable events. Keynote speakers for the opening Plenary Session and lunches are some of the most inspiring and renowned figures in the industry. The actual presentations are given in a number of different technical sessions devoted to Steam Generators, Feeders, Fuel Channels, Inspection Programs and Aging Life Management themes to name a few.

The 2003 CANDU Maintenance Conference featured over 60 excellent papers. During the breaks, individuals are able to visit a number of interesting and innovative exhibits from prominent service providers. Exhibitors for the 2005 conference include AECL, B&W, Intech International, Zetec, GE Canada, Nova Machine Products, Shultz Electric, Enertech, Ian Martin, Farris Engineering, Reality Measurements, Canspec, OPG Inspection & Maintenance Services, RCM Technologies, Larslap USA, Nuclear Logistics, Kinectrics and Justram Equipment.

Primary contacts on the 2005 Organizing Committee include:

- Chairman: Brent Murchie ~ Bruce Power (519-361-2673 x 2290 brent.murchie@brucepower.com).
- Technical Program: Marc Paiment ~ OPG Pickering (905-839-1151 x 2108 marc.paiment@opg.com)
- Exhibits and Sponsorships: Mike Schneider ~ Invaritare Data Centre (905-689-7300 mschneider@invaritare.com

Additional details can be found at the Canadian Nuclear Society Website www.cns-snc.ca

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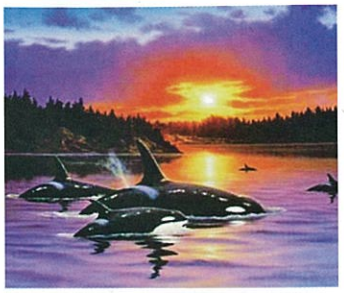
Second call to authors and presentors.

Our first call, which resulted in close to 100 submissions, confirmed the value and interest to proceed with this first of its kind Conference. It has enabled a preliminary program to be developed, with gaps still to be filled from this second call.



Our Vision:

The need to deal in a practical manner with climate change, to adapt to and mitigate against its negative effects, implies the application of engineering and engineers. We are calling on the engineering community to embrace the opportunities and challenges of this phenomenon.

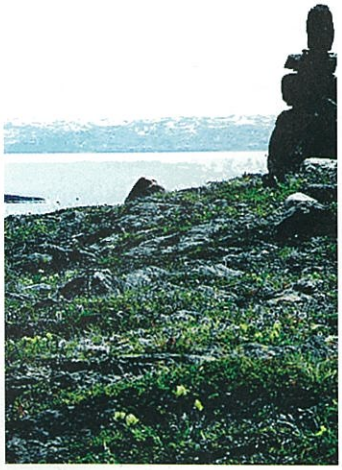
Our Main Conferences Tracks:

- **Policy, Strategy, and Regulations**
- **Measurement, Monitoring and Standards**
- **Engineering for Mitigation (reduction & removal GHG)**
- **GHG Markets and Risk Management**
- **Engineering for Adaptation (design for climate change)**

There will also be sessions on **Modeling and Analysis** and **GHG Education Programs & Strategies.**

Papers and Presentations:

Abstracts are invited for both papers and presentations. We wish to encourage industry participation in the form of presentations.



Important Dates:

Notification of Acceptance - First Call	May 31, 2005
Submission Deadline - Second Call	September 30, 2005
Notification of Acceptance – 2nd Call	November 30, 2005
Authors submit Manuscript for CD ROM	January 31, 2006
Panelists submit presentation for CD-ROM	February 15, 2006
Presentation at Conference	May 10, 11 or 12, 2006

Another Anniversary

GE Canada celebrates the 1955 creation of the Civilian Nuclear Power Department, designer of NPD

Over 200 retirees and companions gathered in Peterborough, Ontario on August 26 and 27 to commemorate the formation of the Civilian Nuclear Power Department (CAPD) of the then Canadian General Electric Company (CGE)

It was in the summer of 1955 that a small group assembled in one of the building of CGE's Peterborough Works to begin the design of the Nuclear Power Demonstration (NPD). There were just 72 members of CAPD in the time between 1955 and 1962 when NPD 2 began operation, yet the design they produced set the pattern for all successive CANDU nuclear power plants.

The celebration began with a dinner on August 26 where the surviving members of the original members of the CAPD team (and some later members) renewed acquaintances. In some cases these were between friends and former colleagues not seen in decades, although some members of the CAPD alumni do meet annually.

Peter Mason, current vice-president of Nuclear Products at GE Canada, served as host. Although relatively new to the nuclear scene Mason had obviously supported the reunion with enthusiasm and allowed his associate Judy Foster time to make most of the arrangements,

Mason welcomed everyone and gave credit to Judy Foster and the volunteer committee headed by Ed Adams, Walter Tarashuk and John Pawliw for all of their efforts. Adams added the greetings of his group, commenting on the difficulty of locating all of the early members of CAPD. Echoing Mason he also praised Judy Foster for her commitment to the project.

Mason noted special guests: Lorne McConnell, first superintendent of NPD and later a senior vice-president at Ontario Hydro; Les Haywood, the most senior of the surviving members of CAPD; and Ken Petrunik, senior vice-president at Atomic Energy of Canada Limited (AECL), the invited guest speaker.

In his talk Petrunik began with a brief summary of CGE and GE Canada's involvement in the Canadian nuclear program, including: NPD; KANUPP (Pakistan); WR 1 (organic cooled research reactor at AECL's Whiteshell Laboratories); the Port Hawkesbury heavy water plant and significant parts of Wolsong 1 in Korea. He then turned to a review of some recent positive aspects of the Canadian program, including Qinshan III project and the good performances of CANDUs in Korea and China.

At the close of the evening each CAPD member was presented with a certificate and a CD containing the 165 page thesis by Gerald Wynne Contello written for his MA at Trent University in 2003, titled *The Role Played by Canadian General electric Company's Atomic Power Departmentin Canada's Nuclear Power Program: Work, Organization and success 1955 - 1995.*

The following morning the group assembled at the current GE Canada's Nuclear Products building for a tour of the offices and the manufacturing facilities for fuel and fuel handling machines. That was followed by a gathering in a large tent erected on the grounds where Peter Mason again welcomed everyone and introduced two special speakers: Lorne McConnell and David Torgerson, senior vice-president at AECL

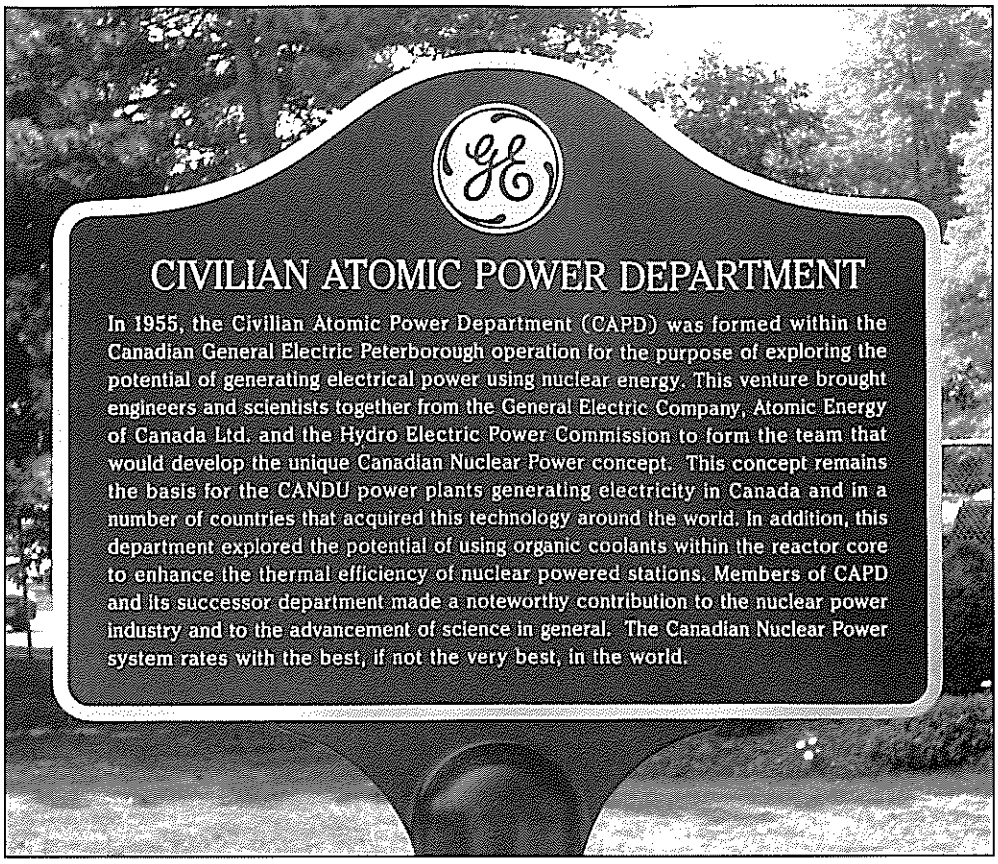
McConnell offered a brief review of the nuclear program in Canada, noting the work of the members of the Montreal Laboratory during the Second World Was and the creation of the Chalk River Laboratories where the NRX research reactor began operation in 1947. AECL was created in 1952 and in 1955 an agreement between AECL, Ontario

Les Haywood, senior pioneer of CAPD and Elyse Allan, CEO of General Electric Canada, are seen just after unveiling a plaque on August 27, 2005, to commemorate the creation of the Civilian Nuclear Power Department of Canadian General Electric in 1955.

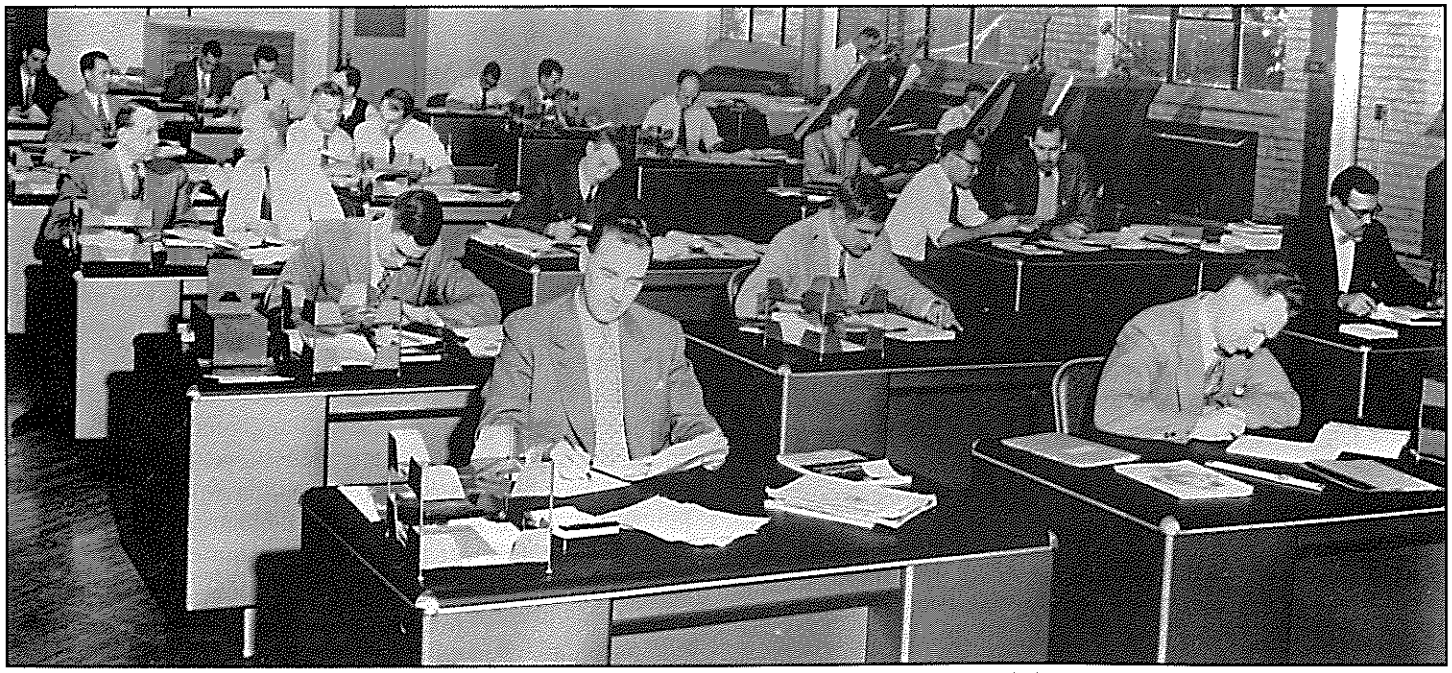
Hydro and CGE led to the creation of CAPD. He noted that the original NPD design involved a pressure vessel. That was scrapped in 1957 to be replaced by NPD 2 that began the pressure tube, on-power fuelling concept of subsequent CANDUs.

Torgerson presented his optimistic view of future prospects for the evolution of the CANDU concept, beginning with the Advanced CANDU Reactor (ACR) currently in design and looking forward to a CANDU - SCWR (super cooled water reactor) and eventually to more exotic designs. Materials will be the limiting factor for the future, he commented.

The group then moved to a spot near the entrance to the Nuclear Products building where Elyse Allan, CEO of General Electric Canada and Les Haywood unveiled a plaque to commemorate the creation of CAPD.



A close-up of the CAPD commemorative plaque



A view of the original CAPD office in summer 1955.

ZEEP: Canada's First Nuclear Reactor

By R.E. Green and A. Okazaki[1]

Ed. Note: *The following is the text version of the presentation by Ralph Green at the Plenary Session III of the 26th CNS Annual Conference held in Toronto, Ontario, June 2005. A replica of ZEEP has been constructed at the Canadian Museum of Science and Technology in Ottawa.*

Abstract

In 1905 Albert Einstein published his historic paper on special relativity, which contained the equation E=mc 2. The significance of this mass-energy relationship became evident with the discovery of nuclear fission in 1939, when it was realized that large amounts of energy would be released in a fission chain reaction. Canadian scientists were involved in this field from the beginning and their efforts resulted in the startup in September 1945 of the ZEEP reactor at Chalk River, the first reactor to go critical outside the USA. In this paper we recall some of the events that led to the construction of ZEEP, and describe the role it played in the development of the Canadian nuclear energy program.

Introduction

One hundred years ago, Albert Einstein took the world of physics by storm when he published three outstanding papers on widely different areas of physics. In one of these papers he formulated his special theory of relativity which contained the now famous mass-energy relationship E = mc 2.

During the next three decades the work of Rutherford, Bohr, Heisenberg and others revealed the structure of the atom. The discovery of the neutron in 1932 by Chadwick provided Fermi and others with a means for probing the nucleus, which resulted eventually in the discovery of nuclear fission in 1939. With this discovery, the real significance of Einstein's mass-energy relationship became clear, since scientists now realized that large amounts of energy would be released in a nuclear chain reaction.

Canadian scientists were involved in this field right from the beginning and their work resulted in the startup of ZEEP (Zero Energy Experimental Pile) on September 5, 1945, the first nuclear reactor to operate outside the USA. In this paper we recall some of the events that led to the construction of ZEEP, and describe the role it played in the development of the Canadian nuclear program.

ZEEP: Conception To Criticality

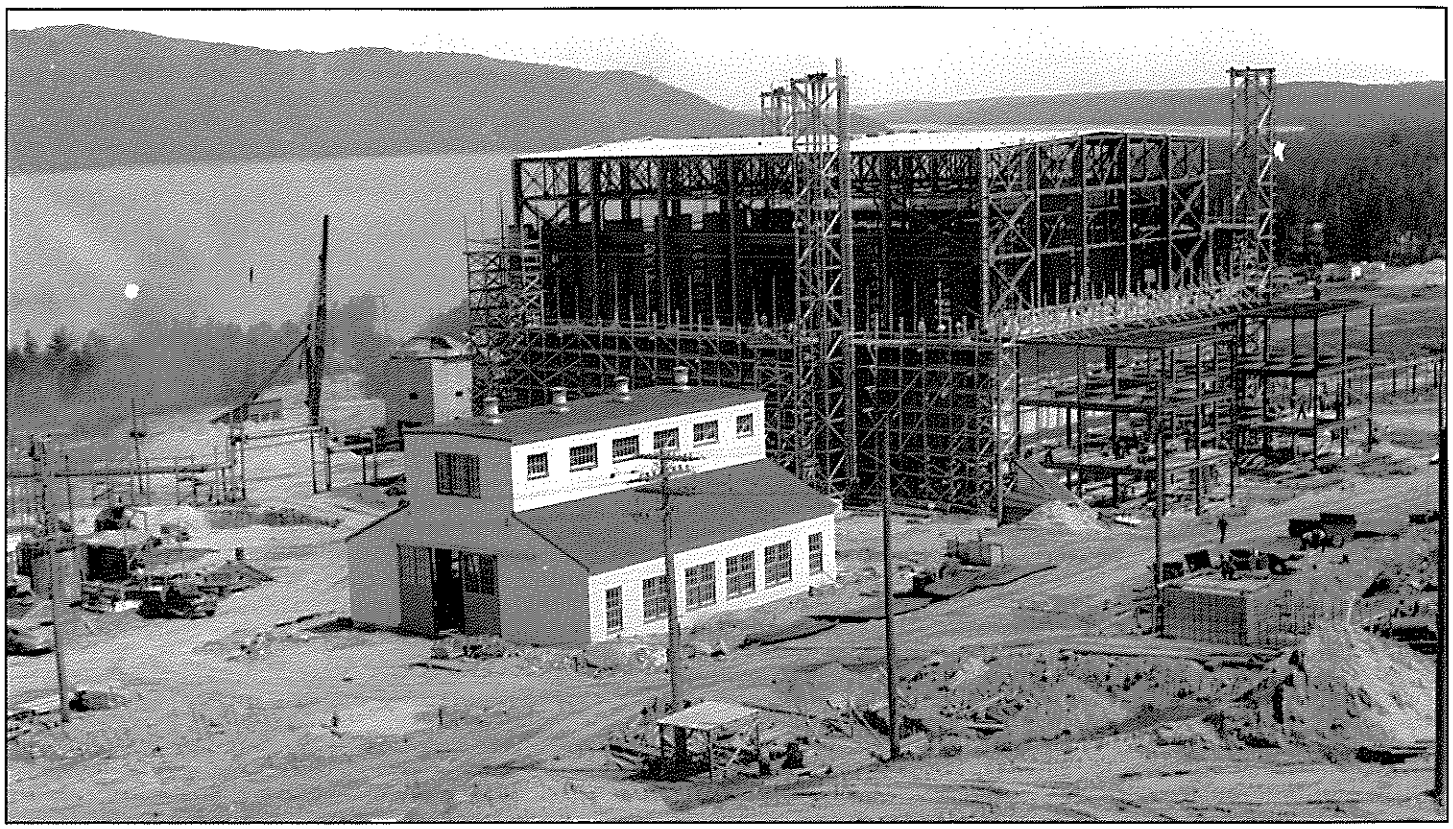
The first attempt to achieve a self-sustained nuclear chain reaction in Canada was made by George Laurence, assisted by B.W. Sargent, working at the National Research Council in Ottawa during the years 1940-42. Their pile consisted of sacks of uranium oxide interspersed with sacks of powdered coke. Their attempt failed mainly because of impurities in the materials they were using, although it would have been very difficult to achieve a critical assembly using natural uranium oxide and graphite, even with pure materials.

In 1942 it was decided to move the UK nuclear-energy program to Canada, and a joint Canada-UK laboratory was set up in Montreal in the fall of 1942. The work in Montreal, described in a pamphlet entitled "Early Years of Nuclear Energy Research in Canada", by George Laurence, led to the decision, in mid-April 1944, to build a natural-uranium-fuelled, heavy-water-moderated reactor, what we know today as NRX. The design of NRX was based on theoretical calculations, backed up by subcritical experiments in the Montreal laboratory using lattice arrangements of natural-uranium metal rods immersed in heavy water.

In late April 1944 John Cockcroft came to Canada to lead the Canada-UK program. In May 1944 Cockcroft decided it would be desirable to have some operating experience with a low power reactor like NRX before the latter was built, and to have the capability to alter the reactor core to investigate the effect of changes to the lattice arrangement. The main reasons for building such a reactor were that it could be constructed quickly and the experience gained during the construction and operation would be valuable for NRX. It could also be used to measure some materials properties and to test control, safety and radiation-protection equipment.

So, in July 1944 Cockcroft asked two of his staff to look at the possibility of building a low-power reactor without seriously impeding the NRX project. In August 1944 approval

1 Drs. Ralph Green and Al Okazaki are both retired from Atomic Energy of Canada Limited. Ralph Green lives in Ottawa, Al Okazaki in Deep River, Ontario



A view of the ZEEP building in 1945 with the skeleton of the NRX building behind.

was received to proceed with the design, and Lew Kowarski, newly arrived from the UK, was asked by Cockcroft to manage the project. Charles Watson-Munro was Kowarski's second in command, and they were assisted by A.H. Allan, F.W. Fenning, G.J. Fergusson, C.W. Gilbert, E.P. Hincks, H.F. Freundlich and H. Carmichael. The chief designer was George Klein from the NRC Mechanical Engineering division in Ottawa. He was ably assisted by Don Nazzer, also of NRC.

During the design phase there was pressure from the research staff for a reactor power of 1 kilowatt, rather than 1 watt, because this would provide neutron fluxes high enough for good cross-section measurements, for the chemists to prepare good radioisotope sources, for the engineers to study material properties and for significant radiation protection work to be done. However, such a power level would require more shielding to protect the operators, and would preclude the rapid rearrangement of the core to study different lattice configurations. So, the power level was kept at 1 watt.

Final approval for the construction of ZEEP was given on October 10, 1944. Construction was complete by September 4, 1945, and the reactor went critical on September 5, 1945 at 3:45 p.m., only 16 months after conception and only 11 months after approval of construction. One might wonder how long it might take to achieve that today. Of course, this was before the creation of the Atomic Energy Control Board (now the Canadian Nuclear Safety Commission).

The height of the heavy water in the ZEEP reactor tank at criticality was 132.8 cm, compared to the calculated value of 128 cm. This excellent prediction was made by John Stewart, a long-time AECL employee, working with George Volkoff, who later went to the University of British Columbia.

As noted above, ZEEP was the first reactor in the world to operate outside the USA, and it was a great achievement for the Canada-UK team. However, it is important to acknowledge the contribution made by the U.S., in providing key materials, and information from the operation of the CP-3 heavy-water research reactor at Chicago.

Early Operation Of ZEEP: 1945-47

Once criticality had been achieved, a busy schedule of experiments commenced, and continued up until early 1947, when ZEEP was shutdown so that its heavy water could be used in NRX.

Space limitations preclude our listing all of the experiments done during this initial operating period, but the major ones were as follows:

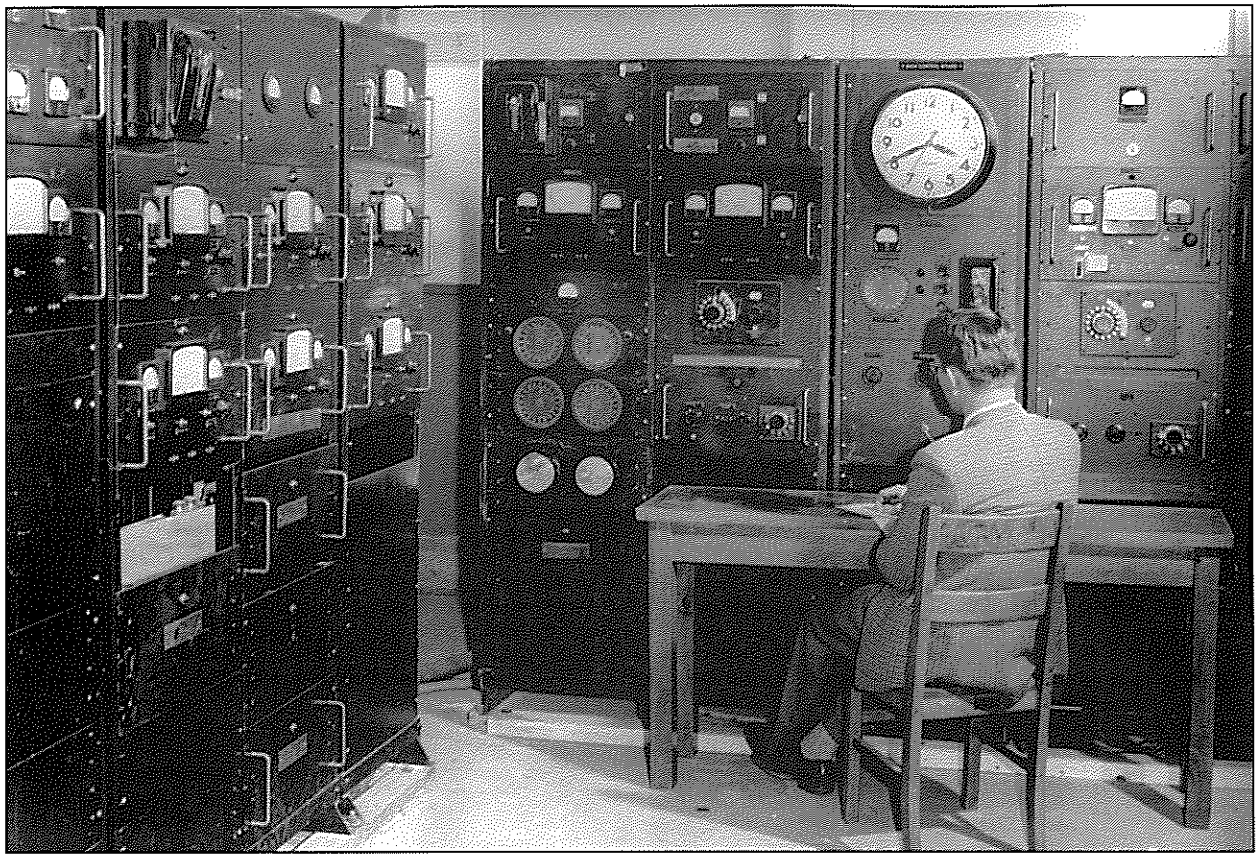
- measurement of the buckling, or overall reactivity, of the ZEEP lattice
- measurement of relaxation and doubling times for various subcritical and supercritical conditions, to determine heavy-water reactor kinetics
- measurement of the temperature coefficient of reactivity
- measurement of intensities and lifetimes of delayed neutrons and delayed photoneutrons, important for reactor control and safety
- calibration of ion chambers for the NRX control and safety systems

A schematic drawing of ZEEP.

- measurement of the reactivity effects of various control-rod configurations, including interference effects between rods
- measurement of the neutron absorption of various nuclear materials, e.g. samples of graphite and uranium for the UK reactors, and thorium for the NRX J-rod annulus, where it was planned to produce uranium-233
- various nuclear-physics experiments, e.g. the measurement of gamma rays emitted during fission, and a search for the negative proton
- determination of eta (the number of neutrons emitted per neutron absorbed) for U-233
- neutron activation of various samples for radiochemical studies. (One of these experiments determined the radioactivity produced in Ottawa River water, which enabled an estimate to be made of the activity to be expected in the NRX cooling water.)

The people involved in these first experiments were: J.G. Bayly, S.W. Breckon, A.J. Cruikshank, F.J.M. Farley, F.W. Fenning, G.J. Fergusson, K.D. George, C.W. Gilbert, H.E. Gove, M.W. Johns, L. Kowarski, B. Kinsey, D.J. Littler, B.W. Sargent, L. Siminovich, A.G. Ward, C. Watson-Munro and D.H Wilkinson.

Since ZEEP initially had no shielding outside the graphite



The original control room.

reflector, it had to operate at first at a fraction of a watt, to protect the operators. Later on, tanks of ordinary water were stacked around the reactor, wood was placed on top and a small room of masonite and steel blocks was built to house the operators. In this way the power could be raised to 50 watts for brief periods. During this first phase of operation ZEEP operated around the clock, except for Sundays, when the reactor was shut down at 7:30 am, presumably to give the staff time to get to church, or to go sailing, or play tennis!

ZEEP was shut down in April 1947, and its heavy water was transferred to NRX. Much was accomplished during this first period of operation, and much of it was relevant to the operation of NRX. However, no experiments were done to study the effect of changing the lattice arrangement, one of the original reasons for building ZEEP. Perhaps there were too many other important experiments to be done, and since the ZEEP critical size had been accurately predict-ed, it may have been decided that the more time-consuming lattice experiments were not required at that time. These would come in the next phase of operation.

Second Period Of Operation: 1950-56

The ZEEP program started up again during the period April-August 1950, under the leadership of A.J. Pressesky. During the shutdown new side shielding had been provided so the reactor could now operate at higher power levels, and improvements had also been made to the control system.

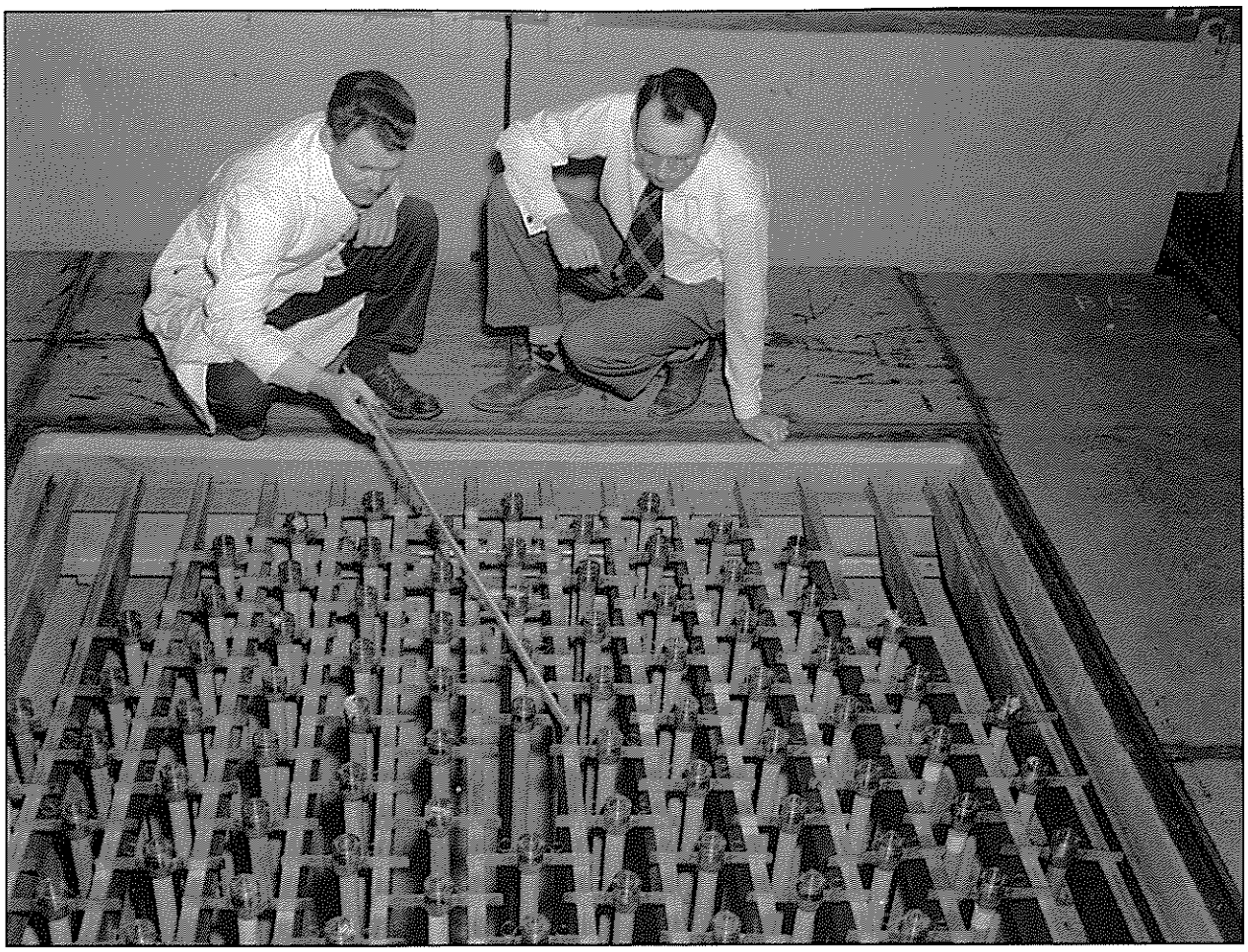
The focus for the experimental program now was support for the new reactor NRU, then being planned. Experiments were done with different numbers of NRU rods and the results were used to optimize the lattice spacing and overall core size for NRU. Other experiments were done to measure the reactivity effects of empty fuel channels and the split lattice used in NRU to provide horizontal through tubes for neutron-beam research. Other NRU-related studies involved measuring reactivity effects and neutron flux perturbations due to the insertion of guide tubes and various control devices.

At this stage in our power-reactor development it was believed important to extract the maximum amount of energy from natural uranium fuel, and to do this would require recycling the plutonium produced in the original fuel. This led to experiments in ZEEP with close-packed lattices that might be used as a blanket around a reactor core to produce plutonium.

There was also interest in power-reactor cores with fuel rods containing large amounts of uranium, so experiments were done with 3-rod clusters of ZEEP rods to investigate this concept.

In another experiment the temperature coefficient of reactivity for the ZEEP core was measured by heating the reactor to 80 degrees Celsius. Measurements of the temperature coefficient of uranium were also made, using the "swing" method, in which samples of heated and unheated uranium were alternately inserted into equivalent positions in the reactor core.

Other experiments were done with Pu-Al rods prepared by John Runnalls and co-workers. This type of fuel was being



A view of the original top of the reactor.

considered for use in NRX and NRU.

ZEEP was also used during this period by scientists from the UK to measure the properties of fuel rods to be used in a proposed UK heavy-water power reactor.

Near the end of this period lattice experiments were done with 19-rod clusters of uranium metal, similar in size to those used later in NPD and Douglas Point. This fuel was produced before it was clear that uranium oxide would be the eventual fuel for CANDU reactors.

The key players during this period of operation were D.H. Allen, W. Dickerson, D.W. Hone, J.H. Moon, A. Okazaki, R.M. Pearce, L. Pease, A.J. Pressesky and D.H. Walker.

The second period of operation was now coming to a close as plans had been made to shut the reactor down for another upgrade. There were several weaknesses in the system that needed fixing. One was that there was no way to drain heavy water from the reactor at the control desk. The reactor was normally started up by pumping heavy water into the reactor tank to a level at which the power would increase at a fixed rate. When the desired power level was reached water had to be drained from the tank to achieve operation at steady power. However, the drain valve was located at the side of the reactor, 10 to 15 feet from the control desk. So, one operator had to manipulate this valve on instructions from a colleague watching the power meter at the control desk. (It should be noted here that the scientific and technical staff were also the operating staff.)

The shielding for the top of the reactor was also primitive compared to today's standards. There were tanks of boron-loaded paraffin that could be placed on the reactor lid, for operation at high power, but since lifting these was no fun the tendency was to operate as much as possible at low power, or for short periods at higher power.

Once when ZEEP was operating without the shielding in place the NRX reactor tripped due to high neutron flux in the NRX reactor hall. After that, we were asked to inform the NRX operating staff when ZEEP was going to operate.

There was also a problem with the ZEEP shutoff rods. These were attached to cables wound on drums mounted on the rod-support beams. Sometimes when these rods were dropped to shut the reactor down the cables would jump off their drums. While this wasn't a safety concern, it did delay the experimental program.

There is one anecdote from that period that readers might find interesting. To pump water into the reactor tank one had to push a button at the control desk to start the pump. However, the pump ran only for a fraction of a minute at a time, and then stopped. So an operator had to repeatedly push the button to keep the pump running. Since this was rather tedious, one of the operators made a block of wood that could be used to jam

the pump button so the pump would run continuously.

One day, a couple of researchers were on the top of the reactor inserting flux detectors, and an operator was at the control desk pumping up the heavy water, with the pump button jammed. Suddenly, the telephone rang at the other side of the building and the operator left the control desk to answer it, leaving the pump running. The call took longer than expected and the next thing the researchers heard was the shutoff rods dropping into the reactor. The reactor had tripped on overpower. No one knows how much radiation the researchers received since they had left their film badges in their coat pockets on the floor below! However, it couldn't have been too much since the wife of one of the researchers later had a healthy baby. One might deduce from this that "a little neutron flux never hurt anyone". This incident was never reported to senior management.

So ZEEP was shutdown for several months at the end of 1956. A new rolling shield for the top of the reactor was installed, as well as new control and safety equipment. The latter was similar to the instrumentation to be used in NRU, so once again ZEEP was used as a test bed.

Third Period Of Operation: 1957-68

ZEEP started up again during the April-June 1957 period. The first series of experiments involved a core of 55 19-rod clusters of uranium oxide. Although the density of the oxide was lower than that used later in the power reactors, it nevertheless enabled us to obtain the first lattice physics data for uranium oxide fuel.

One experiment involved heating the whole reactor to 65 degrees Celsius to determine the overall temperature coefficient.

Later we acquired a full loading of 7-rod clusters of the original NPD uranium-oxide fuel for another series of experiments. This fuel was in the form of 50-cm long bundles, another first for ZEEP.

Tests were done with heavy water and air coolants, which gave valuable information on the reactivity effect of a loss of coolant, information important for the design of CANDU safety systems.

In September 1960 the ZED-2 reactor started up, and from that time forward most of the full-scale lattice experiments were done there. ZED-2 was large enough that experiments could be done with complete fuel-channel assemblies, i.e. with pressure and calandria tubes. However, the role of ZEEP was far from over. A hot loop was installed at the centre of the reactor and was used to measure detailed neutron-spectrum effects in CANDU fuel at elevated temperatures, closer to the actual conditions in the power reactors.

During this period a series of experiments was done to check the feasibility of determining lattice parameters by using a small number of fuel assemblies located at the centre of a large core of different assemblies. This substitution technique was of interest since it would, if feasible, reduce the amount of new fuel required for such work in the future.

Many other valuable experiments were done in ZEEP during this final period of operation. Some of the more significant ones were:

- measurement of the reactivity of several NRU fuel assemblies, in an attempt to explain a loss of 7 mk in reactivity when a new fuel design was introduced in NRU. (The reactivity loss was found to be due to boron contamination of the aluminum coolant tubes.)
- measurement of flux peaking at the gaps between the ends of adjacent CANDU fuel bundles. (The fuel engineers were concerned about fuel overheating at the bundle ends.)
- a comparison of the neutron absorption of samples of Zircaloy, Zr-Nb and ozhennite, prospective pressure-tube materials
- irradiation of sulphur capsules for the Commercial Products Division of AECL (now MDS Nordion), to explore ways to enhance the production of phosphorus-32
- tests of self-powered flux detectors being developed by J.W. Hilborn
- the reactivity of Douglas Point-type fuel bundles for the CANDU reactors in India

We are now up to the end of 1968, and from here on ZEEP was used only sporadically, as all of the lattice physics work was being done in ZED-2. From this point until its final shutdown the reactor was used mainly by university students for post-graduate projects.

ZEEP was shut down for good on July 27, 1970, after almost 25 years of outstanding service.

The major players in this last phase of operation were D.H. Allen, G.A. Beer, C.B. Bigham, D.S. Craig, B.G. Chidley, W. Dickerson, R.E. Green, K.J. Hohban, D.W. Hone, B.A. Maciver, A. Okazaki, R.J. Patterson, D.J. Roberts, L.P.Robertson, K.J. Serdula, P.R. Tunnicliffe, R.W. Turner, D.H. Walker and S. Yewchuck.

Conclusion

In this paper we have tried to take you back in time to the early days of the Canadian nuclear program, and to give you a summary of the history of ZEEP, whose 60th anniversary we are celebrating this year. We hope you will agree that while ZEEP was a small reactor, it was a very versatile one, and made a large contribution, out of all proportion to its size, to the Canadian nuclear program.

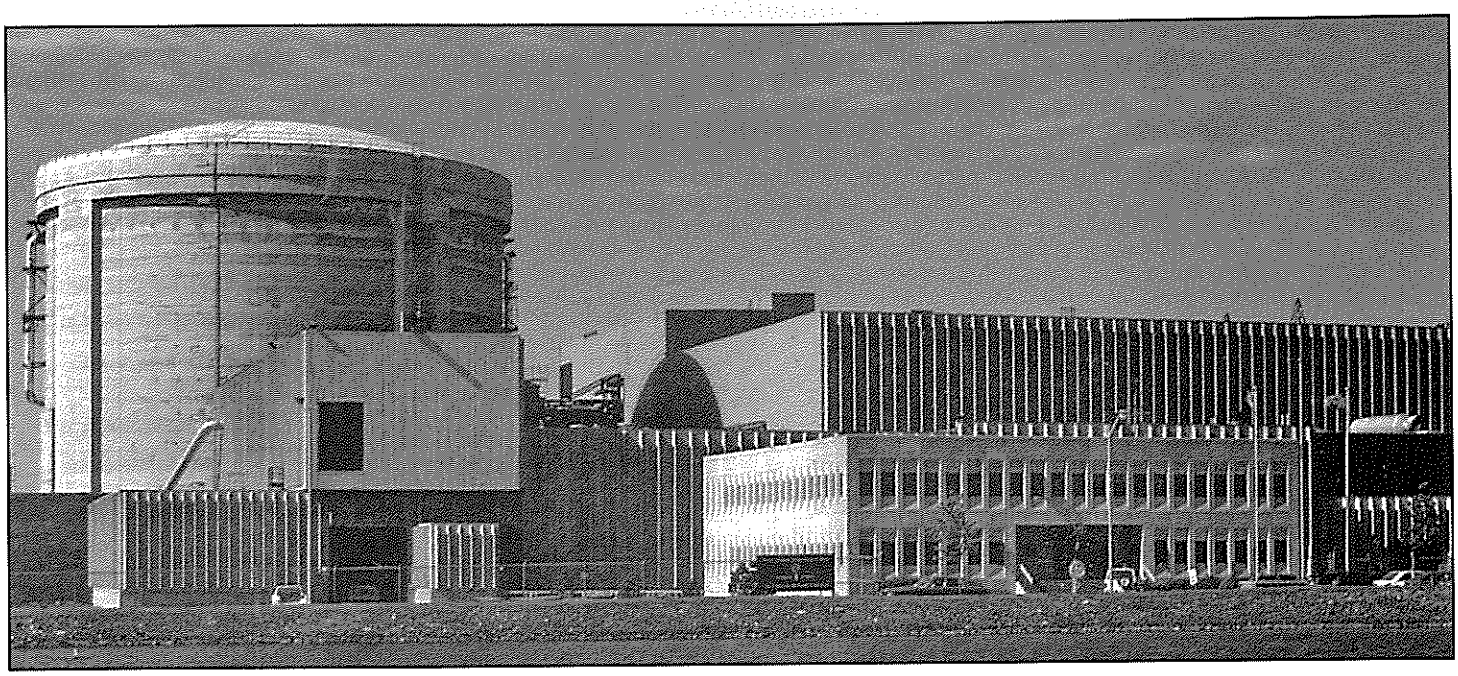
It represented the first self-sustained nuclear chain reaction in Canada, the first outside the USA, and launched us on the road to CANDU, the best power-reactor system in the world.

However, the ZEEP story is not yet complete, for the reactor is currently being reassembled at the Museum of Science and Technology in Ottawa, and it is hoped to have the reactor open for public viewing this fall (2005).

26th CNS Annual Conference, June 2005

Point Lepreau Refurbishment - Update 5

By R.M. White, E.R. Eagles, C.N. Hickman, R. Baker and P.D. Thompson[1]
and J.Q. Howieson and N. Ichiyen[2]



Summary

NB Power Nuclear is planning to conduct an 18-month maintenance outage of the Point Lepreau Generating Station (PLGS) beginning in April 2008. The major activity would be the replacement of all 380 Fuel Channel & Calandria Tube Assemblies and connecting feeder pipes. This activity is referred to as ***Retube.*** NB Power Nuclear would also take advantage of this outage to conduct a number of repairs, replacements, inspections & upgrades (such as rewinding or replacing the generator, replacement of shutdown system trip computers, replacement of certain valves & expansion joints, inspection of systems not normally accessible, etc). These collective activities are referred to as ***Refurbishment.*** This would allow the station to operate for an additional 25 to 30 years.

The scope of the project was determined from the outcome of a two year study involving a detailed condition assessment of the station which examined issues relating to ageing and obsolescence, along with a detailed review of Safety & Licensing issues associated with extended operation.

The Refurbishment outage would be preceded by a detailed Engineering Project Phase that would:

- Finalize details of the Retube process including modeling, tooling development, site facilities and training of personnel
- Perform necessary engineering activities related to design modifications
- Construct the new waste storage structures to house Retube Waste and other additional waste storage structures for the extended life of the station
- Setup necessary temporary construction facilities (offices, storage areas, change rooms, decontamination an maintenance areas) to support Retube
- Procure equipment & components
- Perform detailed outage planning
- Initiate development of detailed commissioning as well as lay-up, monitoring and return to service procedures

At the present time, the NB Power Nuclear Board of Directors and the New Brunswick Provincial government are reviewing a proposal for a lease arrangement from Bruce Power that would also require Bruce Power to refurbish the station. The final decision on project approval is expected in the spring of 2005. NB Power Nuclear continues to progress a limited scope of work on activities important to reducing the overall project financial risk.

Further details on the project are provided in the following sections of the paper. It follows on from the information

1 NB Power, Point Lepreau Generating Station, P.O. Box 600, Lepreau, NB E5J 2S6

2 Atomic Energy of Canada Ltd., 2251 Speakman Drive, Mississauga, ON L5K 1B2

presented at the previous four Annual Conferences of the Canadian Nuclear Society (References 1, 2, 3 & 4).

Importance of PLGS to NB Power

Point Lepreau Generating Station has operated well since start of commercial operation in early 1983. With a lifetime capacity factor of 82.6%[3], it has proven to be an economic and environmentally sound source of electricity generation. The station provides about a third of the power consumed in the province of New Brunswick. It has a significant positive economic impact in the southern part of the province, employing over 600 people and having an annual operating budget of over 100 Million dollars. In addition the station is an important element in achieving environmental emission limits.

Need for refurbishment

Although the station continues to perform well, key reactor components (the pressure tubes and feeders) are nearing the point in time in which they will beed to be replaced. Although pressure tubes and feeders can (and have been) replaced on an individual basis, the number of tubes requiring replacement increases significantly starting about 2008-2010, making the economics of continued operation during this time less and less favorable. For this reason the refurbishment outage is planned to start in April 2008.

Scope definition study - Phase I

In order to arrive at a decision as to whether or not to refurbish the station, NB Power spent two years and 40 M$ determining the scope and cost of refurbishing the station so that ic ould be operated for an additional 25 to 30 years. The study determined the necessary plant modifications by performing a comprehensive review of plant systems, structures and equipment to address issues relating to ageing and obsolescence (Reference-5). The majority of the plant components were found to be capable of supporting extneded operation without needing replacement or changes.

In addition to the Condition Assessment, an extensive review of Safety & Licensing issues was also performed. This included a review of known regulatory and safety issues, comparison of the station against current codes and standards and comparison of the station against safety related modifications made to more recent CANDU 6 units[4]. Benefit cost analyses (BCA) were performed (Reference-6) to assist the utility in determining which changes were appropriate to include in the project scope. As a Probabilistic Safety Assessment (PSA) for PLGS did not exist at the time for use in the BCA, a risk baseline for the station had to be determined (Reference-7). Extensive dialogue with the Canadian Nuclear Safety Commission staff was also undertaken during this phase. A comprehensive Licensing Framework was produced upon which the CNSC provided feedback to NB Power. This feedback was important in terms of achieving clarity of the regulatory position and thus to minimize the financial risk associated with regulatory uncertainty (Reference 16).

NB Power also undertook an extensive public information program so that the general public and key stakeholders were made aware of the tentative plans to refurbish the station (Reference-13).

Project description

If project approval is obtained, the project would undertake detailed design, outageplanning and procurement. This is referred to as Phase-2 of the project. This phase also includes the conduct of the PSA (Reference-8) and certain additional specific deterministic safety analyses (Reference-16). During this time period, construction of temporary facilities to support Retube would also take place, as would the intended modifications to the waste facility.

The third phase of the project is the refurbishment outage itself. During the 18-month period, the Fuel Channels, Calandria Tubes and the complete feeder system back to the headers will be replaced. This overall activity is referred to as "Retube" and it is the most capital and time intensive activity planned for the refurbishment outage. An important aspect of the Retube process is the volume reduction of the Pressure Tubes and Calandria Tubes that will take place as these components are removed from the reactor core. This greatly simplifies the shielding, transfer and storage requirements relating to the waste. Further details on Retubing are provided in Reference-9.

In parallel to the Retube activity, there would also be a number of other design changes and component repair/replacements (example, replacement of shutdown system trip computers and the rewinding/replacement of the generator, etc.). A summary of the overall project scope is provided in Appendix I.

When the project was initiated the outage was tentatively planned to start in the spring of 2006. Information from inspection programs at the station allowed the outage start date to be deferred by two years. This decision to delay the outage will provide additional revenue to NB Power from the station and will allow the project team to advance work on key items to reducing the overall financial risk of the project. This work is referred to as Phase 2 "early start activities" and covers the time period from January 2002 to January 2005.

Accomplishments to date

The developments to date in phase 2 early start activities include:

- Issuance of the overall project Quality Assurance Plan which indicates the relationship between the NB Power Nuclear Management Manual, quality processes and the AECL Refurbishment Project Quality Assurance Manual and plans

3 Capacity Factor for in-service since March 1983 up to the end of 2004.

4 More specific scope information is provided in the Appendix-II.

5 Although the trigger was the modification of the Operating Licence for the waste facility, the assessment Report addressed the modification of the waste structures and facilities, the activities that generate the waste, other refurbishment activities, and the incremental effects of continued station operation.

- Successful completion of a CNSC audit related to Phase-1 Safety scope definition, and an external audit related to the field implementation of the AECL project QAM and the associated detailed design activities of the waste site extension
- Establishment of a formal program by the NB Power project management team to monitor and manage project risks
- Review of lessons learned from other projects
- Issuance of the Phase 2 & 3 Project Execution Plan and update of the integrated project schedule
- Conduct of an extensive Community Relations Program (Reference-13)
- Completion of the detailed design of the additional structures to be constructed and operated at the on-site Solid Radioactive Waste Management Facility to support Retube and extended station operation (Reference-14)
- Completion and approval of the Federal and Provincial Environmental Assessment (Reference-17)[5]
- Receipt of revised Waste Site Operating Licence related to the additional structures
- Continued to refine the Retube process by demonstrating through actual testing, the performance of the volume reduction tooling, and examining ways of optimizing fuel channel removal, and studying Calandria Tube rolled joint removal (Reference-9)
- Continued work on the Fuel channel design details, including work related to the qualification of Seamless Calandria Tubes (Reference-15)
- Completion of Volume Reduction System contamination control testing and detailed development of the complete feeder system replacement process
- Advanced work on the PSA (Reference- 19). This has included extensive interaction with the CNSC resulting in overall agreement with the PSA methodologies.
- Performed detailed and extensive station walk-downs related to analysis of station fires, floods and seismic capacity.
- Finalized methodologies and progressed specific deterministic Safety Analyses in support of trip coverage improvements (Reference 20) and assessment of SDS1 depth for fresh core.
- Advanced work on overall modification to the shutdown systems including the approach to be taken on the shutdown system trip computer Programmable Digital Comparator (PDC) development (References 10 & 11). This included extensive interaction with the CNSC leading to their agreement on all the procedures to be used or the software design, verification and validation of the PDC's on both shutdown systems.
- Issued the Human Factors Engineering Program Plan, four Design guides, Human Factors Summary report, along with providing HF support to the various design activities
- Completion of the Integrated Safety Review of PLGS (Reference-12)
- Continued use of the site interface committee to formally monitor and manage the interface between the project and the station
- Testing of cables in support of Environmental Qualification extended life
- Development of guidelines for preparing procedures related to lay-up, monitoring and returning systems to service activities
- Produced a draft revision of Operating Policies & Principles to support the defuelled core state
- Extensive discussions with the CNSC resulting in a clear understanding relating to the licensing framework for the project and the details relating to key project activities such as Retube, fuel channel design, shutdown system and PDC design modifications, Safety Analysis, PSA, Quality Assurance, Risk Informed approach (Cost Benefit Analysis), Operator training, Restart approvals, etc.

Update on Project Approval Activities

Following the release of the Dr. Robin Jeffrey[4] report (Reference 18) that documents his detailed review of the project, NB Power initiated the necessary activities to address the recommendations. Particular emphasis was placed on addressing the three key issues relating to a) improvement of certain aspects of the contracts with AECL, b) investigation of the options for alternative ownership structures, and c) progress the costing of alternate generation backed up by a long term fuel supply contract. These issues are fundamental in determining how the energy from Point Lepreau will be replaced at the end life for existing reactor components (feeders and fuel channels).

To address the first item, a new round of contract negotiations was undertaken between NB Power Nuclear and AECL. These lead to a draft omnibus agreement that improved certain aspects of the Retube and Refurbishment contracts, as well as included fixed price proposals related to replacement of upper feeders, replacement of DCC's and up-rating of the Turbine.

With respect to external investment; an expression of interest from Bruce Power to the New Brunswick government resulted in a detailed review of NB Power Nuclear, PLGS and the Refurbishment Project by Bruce Power. Upon completion of this review, Bruce Power and its stakeholders formally undertook a formal on-site due diligence review.

Following the due diligence process, a proposal was received and formal discussions of the terms of a lease arrangement were undertaken.

A further detailed assessment of the cost and options for a fossil fuel generation alternative was conducted to confirm the life cycle costs of this alternative for use in the economic comparison.

The NB Power Board of Directors has decided that the final evaluation of options should be made between the Nuclear refurbishment with a Bruce Power lease and the best fossil fuel option represented by a new coal fired unit at the existing Belledune Generating Station. At the present time the NB Power Board of Directors and the New Brunswick government are evaluating the impacts of the

Nuclear option with Bruce Power and the clean coal station. Discussions are also underway between the provincial and federal governments relating to possible financial support for refurbishment project in relation to the environmental benefits of nuclear generation.

A final decision on the refurbishment of Point Lepreau Generating Station is expected shortly.

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4. "Point Lepreau Refurbishment– Update 4" by R.M. White et al., paper presented at the 25th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2004.
5. "Point Lepreau Refurbishment: Plant Condition Assessment", by P.J. Allen et al., paper presented at the 22nd Annual conference of the Canadian Nuclear Society, held in Toronto in June 2001.
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9. "Planning of the Retubing of the Point Lepreau CANDU 6 Nuclear Generating Station", by L. Nosella et al., paper presented at the 24th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2003.
10. "Programmable Digital Comparator (PDC) Replacement for SDS1 and SDS2", by N.M. Ichiyen et al., paper presented at the 24th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2003.
11. "Point Lepreau Refurbishment Project, Programmable Digital Comparator (PDC) Replacement for SDS1 and SDS2 – Update 1", by K.G. Fraser, et al., paper presented at the 26th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2005.
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13. "Point Lepreau Refurbishment: Environmental Assessment Experiences and the Role of the Public", by C. Hickman, e. al., paper presented at the 25th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2004.
14. "Possible Refurbishment of Point Lepreau: Management of Retube Waste", by Dr. P. Tume et al, paper presented at the 25th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2004.
15. "Seamless Calandria Tube Development and Qualification", by Aman Usmani et al, paper presented at the 25th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2004.
16. "Refurbishment of the Point Lepreau Generating Station", by P.D. Thompson, R. Jaitly, N. Ichiyen and M.A. Petrilli, paper presented at the 6th International Conference on Simulation Methods in Nuclear Engineering, held in Montreal in October 2004.
17. "Co-ordination of Federal and Provincial Environmental Assessment Processes for the Point Lepreau Generating Station Solid Radioactive Waste Management Facility Modifications", by C.N Hickman, P.D. Thompson and J. Barnes, paper presented at the Canadian Nuclear Society conference on Waste Management, Decommissioning and Environmental Restoration for Canada's Nuclear Activities: Current Practices and Future Needs, held in Ottawa in May 2005.
18. "Point Lepreau Refurbishment Review", prepared by Dr. Robin Jeffrey, April 16, 2004.
19. "Advances in CANDU PSA for the Point Lepreau Refurbishment Project", by. R.K. Jaitly et al., paper presented at the 26th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2005.
20. "Trip Coverage Improvements for the Point Lepreau Refurbishment Project", by. A. Ranger et al., paper presented at the 26th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2005

Appendix I
Refurbishment Scope Summary

Retube related design changes

The need to replace the fuel channels and the complete feeder system back to the headers is the central driver for the overall refurbishment project, and the replacement of these components will be the major activity during the refurbishment outage. This work also sets the overall outage duration. The design changes directly related to this activity are:

- Replace Fuel Channel assemblies and feeders with components based on Qinshan design
- Replace the existing seam welded calandria tube design

if a seamless design can meet the design requirements and subsequently qualified
- Replace all inlet and outlet feeders (tightening up the material, manufacture and installation technical specifications to address existing issues of flow assisted corrosion and postulated cracking mechanisms)
- Temporary structures to support the Retube Activity
- Additional structures at the on-site Radioactive Waste Management Facility for storage of removed reactor components

Other design changes:

Replace/Modify PDC Systems in Both Shutdown Systems

The Programmable Digital Comparators on both shutdown systems have been assessed as impractical to maintain over an extended station life. As a result, it has been decided to replace both the SDS1 & SDS2 PDC's.

SDS1 Trip Coverage Improvements

To improve coverage for moderator related events involving leak, loss of circulation and loss of cooling, a Moderator high/low level trip will be added to SDS1. Modification to certain other set-points to improve operational flexibility will also be performed.

SDS2 Trip Coverage Improvements

To improve coverage for moderator related events involving leak, loss of circulation and loss of cooling, a Moderator high/low level trip will be added to SDS2. To provide improved coverage for loss of flow events in the heat transport system, an SDS2 high pressure trip on Reactor Outlet Headers 3 and 7 will be added. Modification to certain other set-points to improve operational flexibility will also be performed.

Moderator Subcooling Margin Improvement

Upgrades to the moderator heat exchanger to achieve 100% of the of the Re-circulated Cooling Water (RCW) flow by incorporating additional sealing strips and rods will be performed to improve the moderator sub-cooling margin. This will increase the confidence in crediting the moderator to act as a heat sink for LOCA scenarios.

Shield Cooling System Improvement

A rupture disk on the top of the existing inspection port of the Calandria Vault will be added to provide pressure relief capacity to maintain the pressure within the design limits following a postulated severe accident with loss of moderator heat sink. A remotely operated isolation valve in TK3 outlet line (3W-6) will be installed to eliminate a potential breach of containment via the expansion tank TK-3 under such accident conditions.

HTS Pump Trip On High Thrust Bearing Temperature

A software design change will be implemented to the Heat Transport Pump Trip program that will ensure that the heat transport system pumps are tripped if two of the four RTDs detect high thrust bearing temperature. This will prevent a potential loss of coolant accident due to loss of service water that provides cooling to the pump shaft seals.

Main Control Room Filter System

A filtering system will be added to the Main Control Room ventilation system to protect the main control room's air supply from the potential airborne radioactive contaminants in the event of an accidental release of radioactive material following a severe accident.

Implementation of Seamless Calandria Tube

Qualification testing of the seamless Calandria Tube design has been initiated with the intent that if the tube and process are qualified in time, these tubes will be installed.

Some issues have arisen with respect to the capability of the mechanical joint to withstand the required pressures and the implications are being assessed. This new design could significantly reduce the potential for consequential Calandria Tube failure and moderator drain following a Pressure Tube rupture.

Modify Assembly to Allow Independent Movement of BF3 Start-Up Detectors

This design change ensures that independent movement of the three start-up BF3 counters is provided by the electrical cables attached to each counter in separate compartments, thus allowing two BF3 detectors to continue to function while one is being moved.

Replace Certain RTD Cables

Safety related RTD circuits located within the reactor Building will be removed from the existing PVC insulated cables and replaced using single and multi triad cables complete with dedicated junction boxes. This will prevent a potential drift of RTD signals due to cross talk from power cables under accident conditions of high temperature and humidity.

Replace Underground Fuel Storage Tank with New Design

The underground fuel storage tank for the Emergency Power System diesels will be replaced as it is not expected to last for the extended life of the station. In addition to the original requirements, the new tank will be designed to meet the current New Brunswick environmental standards for underground fuel storage tanks.

Replace Valves In The Moderator Systems

A number of gate valves in the Main Moderator System will be replaced with a qualified design of Neles metal seated butterfly valves. This new design should eliminate leakage and allow these important isolation valves to carry out their function for the extended life of the station.

Main Generator & Auxiliaries Enhancement

The Main Generator stator and rotor will be rewound. The dryer in the hydrogen system will be replaced. The Automatic Voltage Regulators (AVRs) and Stabilizers in the Excitation Auxiliary System will be replaced with new digital units and the existing excitation Rectifier units will be replaced with new units.

Replace Turbine Controls With More Modern Controllers

The Turbine Electro-Hydraulic Governor system, Turbine Supervisory System, and the Turbine Mechanical Over-speed system will be replaced with modern electronic systems.

This change will ensure continued high reliability throughout the extended life of the station.

Component Replacement & Repairs

In addition to the design changes identified above, certain component replacement and repairs will take place. These involve:

Replacement Of Inverters And Rectifiers In The Uninterruptible Power Supply System (UPS)

The Staticon Inverter and the Rectifier equipment associated with the Uninterruptible Power Supply system will be replaced as the present UPS equipment has been assessed as being impractical to maintain over an extended station life and therefore needs updating.

Raw Service Water (RSW) System Refurbishment

In order to ensure long term continued reliable operation of the Raw Service Water System, work to address the age related degradation will be performed. This includes inspection and refurbishment of various valves, replacement of all expansion joints and certain sections of piping, as well as inspection and recoating certain sections of piping.

Re-Circulated Cooling Water (RCW) System Refurbishment

In order to ensure long term continued operation of the Re-circulated Cooling Water System, the various valves in the system will be inspected and refurbished as necessary and the six expansion joints will be replaced. To enable this work to be performed, a temporary cooling system for the Spent Fuel Bay will need to be provided.

Refurbish Shutdown Cooling Pump By-Pass Valves

Certain Shutdown cooling bypass valves will also be inspected and refurbished as necessary.

Dousing Tank and D2o Storage Tank Liner Refurbishments.

The NORMAC liner on the dousing tank will be re-applied to repair small blisters that have formed during past reactor building pressure tests. The Refurbishment outage also provides an opportunity to replace the D2O storage tank internal epoxy lining when the tank is in its drained condition. A damaged lining may expose the base metal to the content of the tank, which can adversely impact the life of the storage tank.

Inspections during Refurbishment outage

In addition to changes and repairs discussed above, certain specific inspections are planned for the refurbishment outage as this is the only time such inspections would be able to be performed. These include inspections of the Shield tank and the Calandria Internals.

Routine Scheduled Outage Work

It should also be noted that in terms of additional outage scope, normal outage work (PMS, testing, call-ups and repairs, etc), will also be conducted, but the full extent of that work will not be known until 2007.

Additional Safety & Licensing Studies:

The additional studies relating to the following will be performed:

- Deterministic safety analysis to cover off certain additional accident scenarios identified in CNSC Consultative Document C-6 Rev. 01
- Deterministic analysis to address the condition of fresh fuel in the core
- Deterministic analyses in support of the design changes
- Completion of the level II probabilistic safety assessments
- Further examination into whether additional instrumentation to increase the defence in depth for severe accidents is cost beneficial
- Further examination into whether or not increasing the defense involving containment response to severe accidents is cost beneficial

APPENDIX II

Key Activities undertaken in the Phase-I Safety & Licensing scope

A: Life Extension
A1: Design Related:
A1.1 Specific studies associated with safety margin improvements:

- Determination of upgrades to Shut down Systems to improve trip coverage
- Determination of changes to address End Fitting ejection
- Determination of changes to reduce the predicted future unavailability of ECC
- Determination of changes to improve moderator subcooling margin

- Review of changes to improve two phase thermosyphoning

A1.2 Studies to determine whether or not additional safety improvements should be made

- Review of PLGS against Safety related design changes for Wolsong/Qinshan
- Review of PLGS against generic CANDU 6 PSA for potential changes
- Review of PLGS design against current codes & standards
- Review of ability of PLGS Safety Systems, Standby Safety Support, and Safety Related systems to meet their unavailability targets
- Review of fuel string gap allowance for LOCA's

A1.3 Economic changes

- Changes to improve CCP/ROP margins

A2 Review of Safety Analysis

- Produce Level 2 PSA work plan
- Review Safety Analysis to determine what analysis needs to be updated (includes review against C6 Rev 1)

A3 Integrated Safety Review

B Work to support the Outage

- Review of OP&P to identify clauses to be changed to reflect defuelled core
- Provide CNSC with overview of commissioning and run-up plan
- Get up-front agreement with CNSC on acceptance criteria for start-up and run-up

C Other support activities:

- Establish Benefit-Cost Analysis Process
- Establish risk baseline for PLGS
- Establish post accident management strategy
- Review of Steam line relocation
- others

Developing People for The New Nuclear Generation

By C. Gordon, R. Fluke, R. Moya[1]

Abstract

The importance of having high-calibre people and the urgency in ensuring adequate numbers of knowledgeable staff has been recognised in the nuclear industry world wide. This paper describes how Nuclear Safety Solutions Ltd. is addressing these challenges by adopting a pro-active approach to training and development. This paper describes the integrated processes and tools used to ensure:

- adequate numbers of appropriately qualified staff to meet current and projected business needs,
- suitably qualified staff are assigned to projects for clients, and
- individual staff development.

NSS uses a Qualification and Experience (Q&E) Registry to ensure the proper functioning of these processes.

I. Introduction

The importance of having high-calibre people and the urgency in ensuring adequate numbers of knowledgeable staff has been recognised in the nuclear industry world wide.

Most industries, and the nuclear industry in particular, demand qualified people. Quality management standards define a requirement for qualified people to perform work, e.g.

- ISO 9001:2000 [1] "Personnel performing work affecting product quality shall be competent on the basis of appropriate education, training, skills and experience."
- CSA N286-05 [2] "Personnel shall be competent to do the work assigned to them.

Competence shall be assessed through the evaluation of education, training, skills, experience, and ability."

However, the OECD Nuclear Energy Agency in 2000 found that nuclear education in most countries had declined to the point that expertise and competence in core nuclear technologies were becoming difficult to sustain [3]. A subsequent report [4] found that there has been progress, but no breakthroughs so that the provision of necessary specialist nuclear education is under threat and attracting high quality technical graduates into the industry is a challenge. The IAEA has also recognised the importance of knowledge management in the nuclear context. For example, the call for papers for the upcoming 2005 IAEA Workshop on Managing Nuclear Knowledge [5] notes:

> "... attracting young blood, retaining staff and attracting experts from other sectors in the face of competition from industries perceived as more attractive is proving problematic in many countries."
>
> and
>
> "Recent positive trends in the nuclear power industry include continuing new construction in Asia, a return to new construction in Europe, new plants being seriously discussed in North America, plant life extensions being implemented for many existing plants, improved operational and safety performance of plants overall, and innovative designs being developed through the Gen IV initiative. **The success of all of these efforts depends upon having sufficient well-qualified personnel for their implementation.**" [emphasis added]

Nuclear Safety Solutions Ltd (NSS), as part of the nuclear industry, must meet the quality requirements and also faces these challenges. NSS is a customer-focused consultancy, with a proven track record in providing value-added, state-of-the-art analytical, engineering, and risk management services in a wide range of fields. Clients choose NSS because it delivers to cost, schedule and required quality, and they recognise and respect the qualifications, skills and experience of its staff. Maintaining and developing that expertise is fundamental to the business.

This paper describes how NSS is addressing the challenge of developing people for the new nuclear generation.

II. Integrated Approach To Training & Development

Figure 1 illustrates the integrated approach to training and development employed by NSS.

This approach requires that the key processes are defined and maintained:

- Recruitment and training
- Assignment of staff to projects
- Staff training and development.

It also relies on developing and maintaining supporting tools, in this case the Qualifications and Experience (Q&E) Register.

III. Qualifications And Experience Register

The Qualification & Experience Register (Q&E) is a database developed by NNC and employed and extended by NSS. It contains, for each employee, a record of:

1 Nuclear Safety Solutions Ltd., Toronto, Ontario

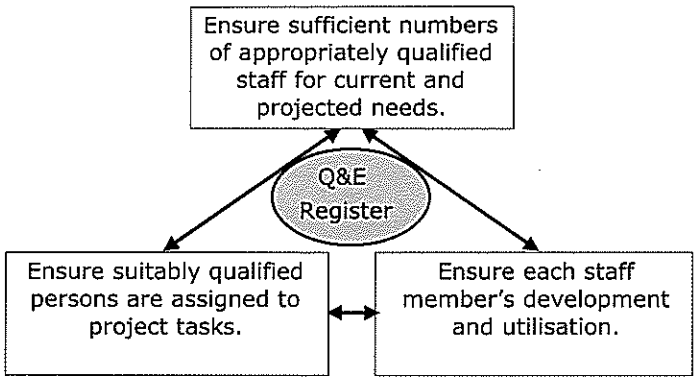

Figure 1: Integrated Approach to Training & Development

- education,
- skills,
- experience,
- training, and
- training and development plans.

The Q&E is used:

- to record staff qualifications
- to identify staff with qualifications needed for a project
- record critical competencies needed for the business and staff with these competencies
- record and monitor individual training and development plans

The Q&E is a database of staff skills and experience, and the extent or level of competency for each. The member's Q&E record is maintained by the staff member who enters 'attributes' such as skills and experience based on a common set defined for NSS. They also enter the competence level they feel they have attained, such as "Can perform the technical competence unsupervised" for skills or "Comprehensive level of experience (>5+ years)" for experience.

A formal process is used to assess qualifications claimed by staff. At the moment it is focussed on current critical competencies which have been determined for the company (see Section 3). The critical competencies that are assessed will grow with business needs. The assessors are selected from senior experts in the area. The assessor reviews the evidence that supports the staff member's claim. These evidence options used are shown in Table 1. Documented guidelines have been developed for assessments.

The assessments and the basis for assessment is recorded in Q&E for future reference.

IV. Ensure Sufficient Numbers Of Qualified Staff

The processes involved in the integrated approach to training and development in NSS are expanded in Figure 2. The steps in ensuring sufficient numbers of qualified staff is shown in the upper right hand segment of the figure.

The Q&E database is used to identify and assess the current technical capabilities of staff in the company, i.e. skills and experience, number of staff with these, level of competency of each. The state of the business is reviewed to assess the technical capabilities needed for current and projected clients in existing lines of business. In addition, extensions or new lines of business as identified in the company's three year Business Plan are considered, and the technical capabilities needed for these are assessed. The output from this exercise is a set of critical competencies and the numbers of staff needed with these.

The Q&E is again used to identify gaps and vulnerabilities:

- not enough qualified staff with a critical competency;
- vulnerability due to too few staff with a critical competency (lack of depth);
- vulnerability due to upcoming retirements.

Using this information, recruitment plans and staff development plans to address vulnerabilities and close gaps

Personal knowledge	The assessor having seen the member working on a project using the ability he/she is claiming.
Documents	Documents, reports and calculations etc. that have been produced verified or approved by the member.
Certificates	An academic qualification, institute registration or any other original certificate.
Verbal questioning	By interview where the assessor can question the member on his/her knowledge of the subject.
Written questions	By e-mail or other written means where the assessor can question the member on his/her knowledge of the subject.
Witness testimony	Provided by the member's in-line manager or other responsible person who can confirm the member's claim.
Historical	Evidence collected several years ago, for example with another employer, but is still considered to be relevant.
Other	Any other type of evidence that will support the member's claim will be acceptable providing it has been agreed by a technical or business Director or the Director of HR as appropriate. The 'Comments' box may also be used by the assessor to write any supporting comments or clarification he/she may have.

Table 1 Evidence Options for Assessing Attribute Claims in Q&E.

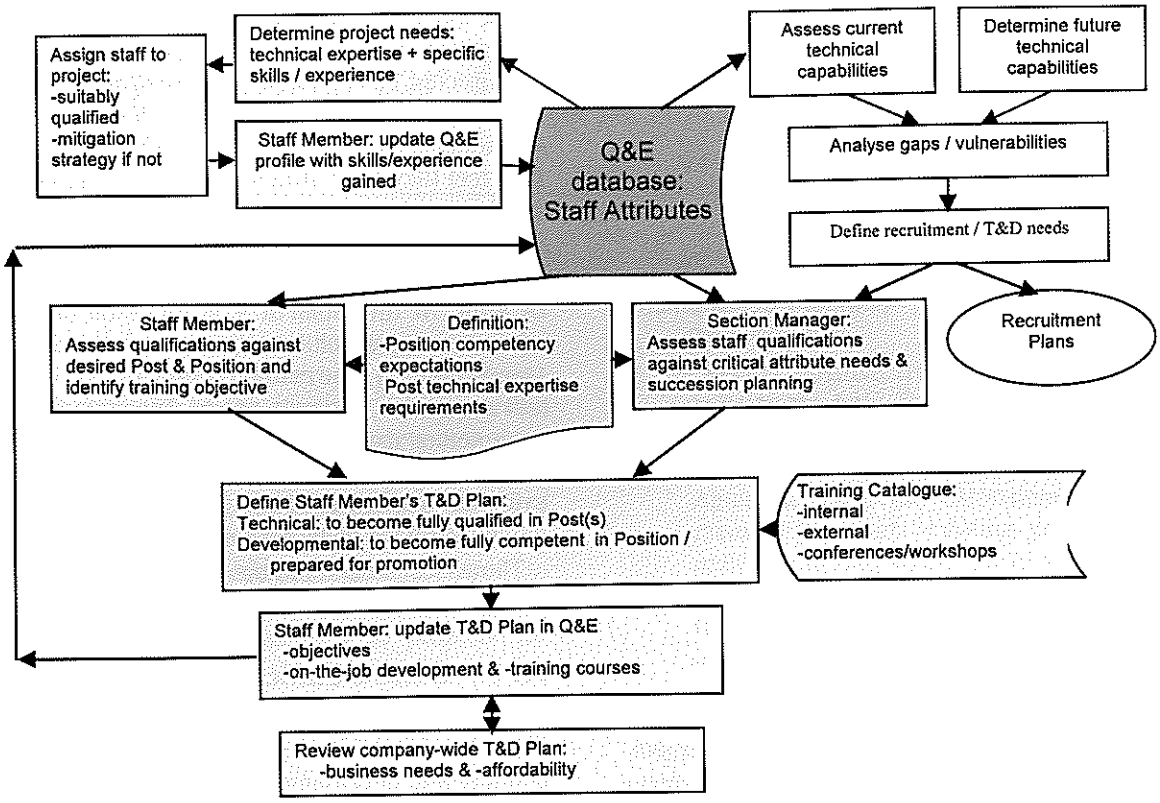

Figure 2: Process Steps in the Integrated Approach to Training & Development

are developed. Staff training and development plans are discussed in Section 5. Recruitment considers both bringing in new staff for development and hiring experienced people with the expertise considered necessary but lacking in the company.

V. Assign Suitably Qualified Staff To Projects

The steps in the process for selecting staff for projects are illustrated in the upper left hand segment of Figure 2. Once a project has been approved for execution, the Q&E is used to identify suitably qualified staff that may be available for project work. The Project Manager defines the attributes (skills, experience, knowledge of regulatory requirements, etc.) needed for each task, and the Section Manager uses Q&E to identify staff with the necessary qualifications. The next step is for the Project Manager to discuss with the appropriate Section Managers the qualifications and availability of staff. In most cases, suitably qualified staff will be able to undertake the work. In some cases it will be necessary to develop a strategy if the available staff are not fully qualified. This could involve, for example, specific training, expert coaching, guidance and review, additional out-of-project training budget for self-study on methodology, codes and standards, or recruitment of new or contract staff who have the necessary qualifications.

Q&E also supports the specification of a Post. A Post is a pre-defined or standard collection of attributes that can be used to facilitate identification of qualified staff. An example could be a 'thermalhydaulics analyst post' which would be someone (regardless of where they are organisationally in the company) who has a sound understanding of fluid mechanics, thermodynamics, etc., and is able to run one of the large analysis codes employed within NSS. As staff become more experienced and more flexible in terms of work they can carry out, it is important to have a systematic approach and supporting tool to be able to identify staff with basic expertise who may be available to take on projects, and not solely rely on traditional functional units to provide this expertise.

VI. Ensure Development Of Each Staff Member

As noted above, attracting high calibre young people, developing their expertise, and retaining them in a competitive economy is a major challenge for the nuclear industry. NSS is committed to the development of its staff through an active Training and Development Program. The primary program objectives are:

- To maintain and grow our capability/expertise in areas relevant to our customers' needs,
- To stay current in our areas of expertise so that we can offer our customers the best advice and support,
- To develop new areas of expertise (or refresh old, untapped, expertise) to create new market areas,

- To promote innovation and creativity through personal development,
- To enable staff to achieve their full potential, and
- To develop staff to meet succession planning needs for technical, business/commercial, and managerial positions.

With the expectation that staff have an important role in planning their own development and that training and development should be closely aligned with the needs of the business, the steps illustrated in the lower segment of Figure 2 are undertaken.

Each person does a self-assessment against the competencies expected of the position they are in or to which they wish to be promoted and the technical expertise of Posts (Section 4) for which they wish to become qualified. The former is related to responsibilities and remuneration and the latter to technical capability. Staff are encouraged to be flexible and acquire a range of skills and experiences. Based on their self-assessment, the staff member proposes objectives for the next stage of their training and development.

In parallel the Section Manager responsible for the technical area of the staff member assesses the relevant qualifications of all staff and the gaps and vulnerabilities in critical competencies as identified in Section 3. Together, they develop a mutually agreed individual Training and Development Plan that will lead to the person becoming fully qualified in one, or preferably more, technical Posts and fully qualified in the Position they are in, or being prepared for promotion to the next level. NSS provides opportunities for staff which can be built into their Training and Development Plans. For new graduates, the Trainee Program includes:

- Induction and core training courses to provide a basic awareness of clients and the technical work undertaken by NSS,
- Assignment to teams with experienced members who can provide mentoring and guidance,
- Rotation through the various Directorates in NSS to allow trainees to experience a range of work to be able to better determine in which area they would like to begin their career, and to start developing the flexibility that the company values, and
- Assignments at client sites.

On-the-Job Development is central to the NSS training and development program. Varied work assignments, with coaching and direction provided by experienced staff, are key. On the job training hours are allocated to staff, on an as needed basis, to enable them to be able to pick up and learn new skills / knowledge while working on a project. The regular reviews and discussions with supervisors / Section Managers, as noted above, ensure a consistent and managed process for this development. While funding of training hours is provided by NSS to ensure that the client's projects do not bear the cost, it is important to emphasise that this fundamental element of staff development is possible only with the willingness of our clients to accept a team approach to qualified staff for their projects.

In addition to the on-the-job development, NSS provides, and staff are encouraged to seek out, additional opportunities for their own development, such as:

- Internal specialised technical training provided by in-house experts,
- External training, for example training on the use of vendor software,
- Conference attendance, in particular technical experts (and staff aspiring to these positions) are expected to submit papers to journals and conferences,

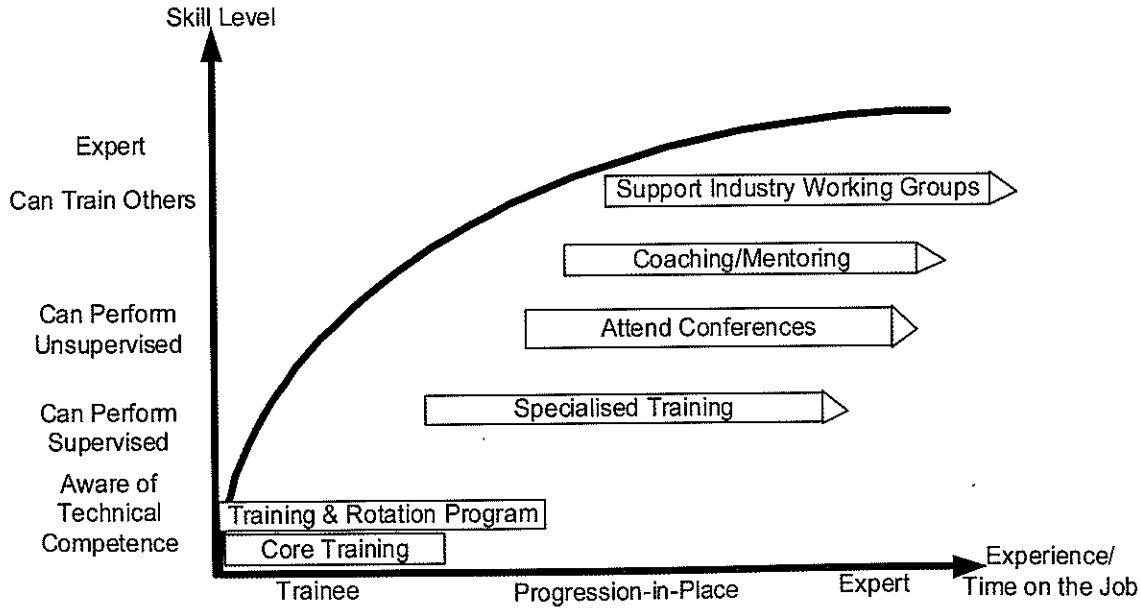

Figure 3: Typical Trajectory of Building Skills and Acquiring Experience

- Support for industry working groups, such as codes and standards committees,
- Self-learning groups, and
- In-house seminars and Lunch & Learn interest presentations.

A typical trajectory of a staff member in developing their skills and acquiring experiences is illustrated in Figure 3.

Once approved, the staff member enters their Training and Development Plan in the Q&E. The individual Training and Development Plans are 'rolled up' to a company-wide level to ensure gaps and vulnerabilities are addressed and the program is affordable. Plans are monitored by the individual and the Section Manager for completion and the cycle repeated. NSS is moving from an annual performance/development review to a more dynamic, ongoing, review using the Q&E to better ensure the development of each staff member.

VII. Conclusion

The importance of having high-calibre people and the urgency in ensuring adequate numbers of knowledgeable staff has been recognised in the nuclear industry world wide. In Canada, with many industry members retiring at the same time as units are being or about to be refurbished, this is an immediate issue that needs to be addressed. Ensuring long-term continuity of knowledge and developing expertise cannot be left to chance. This paper describes how NSS is addressing the challenge of developing its employees.

NSS has adopted a pro-active approach to training and development. It has developed a set of processes and tools to ensure:

- adequate numbers of appropriately qualified staff to meet current and projected business needs,
- suitably qualified staff are assigned to projects, and
- individual staff development.

The Q&E Register is a central tool for ensuring the proper functioning of these processes.

It is with such an integrated approach to staff development that NSS is developing people for the next nuclear generation.

References

[1] International Standards Organisation, "Quality management systems – Requirements" ISO 9001:2000, December 2000.

[2] Canadian Standards Association, "Management system requirements for nuclear power plants", CSA N286-05, February 2005.

[3] NEA "Nuclear Education and Training: Cause for Concern?", June 2000.

[4] NEA, "Nuclear Competence Building – Summary Report", NEA No. 5588, 2004.

[5] IAEA Workshop on Managing Nuclear Knowledge Information Sheet, L1-TM-27258.

Student Conference winners

The 29th CNA / CNS Student Conference was held as embedded sessions during the 26th Annual CNS Conference in Toronto, June 12 -15, 2005. Thirty papers were presented in four sessions over two days.

Following are the winners:

Doctorate:

Supa-Amornkul Savalaxs, University of New Brunswick
Flow Visualization Study of Two-Phase Flow in a Single-Bend Outlet Feeder Pipe and Horizontal Annulus of Outlet End-Fitting of a CANDU Reactor

Masters:

Sivakumar Thangavelu, University of New Brunswick
Flaw Detection by Spatially Coded Backscatter Radiography

Undergraduate:

David Rioux, École Polytechnique de Montréal
Effet Doppler lié à la Température de Combustible dans un Réacteur CANDU

CNS President John Luxat (3rd from left) poses with the winners of the 29th CNA/CNS Student Conference; L to R: Sivakumar Thangavelu, David Rioux, Supa-Amornkul Savalaxs

26th CNS Annual Conference, June 2005

Assessing Human Performance Through A Model-Based Regulatory Approach

By Jean-Yves Fiset and Helen McRobbie[1]

Abstract

In this paper, we propose a new conceptualization for the assessment of human performance for regulatory purposes. This new conceptualization uses a goal-based model to represent the domain to be regulated and a life-cycle model to represent the regulatory activities themselves.

An example is provided. It is argued that a conceptualization of a regulatory approach in terms of models may lead to better coverage of the domain and to improvements in the regulatory effort.

I. Introduction

This paper explains how a regulator can assess processes that support human performance, as well as the implementation of those processes, through a model-based regulatory approach. It is important to note that the methods and techniques described here are not new at the Canadian Nuclear Safety Commission (CNSC). They have been, and continue to be, used to assess licensees' activities in a variety of domains, and in particular in the area of human performance.

What is new is the demonstration of how those methods and techniques can be embodied into a new conceptualization of the regulatory activities and how this conceptualization offers potential for regulatory improvements; this new conceptualization will be termed "model-based regulatory approach".

This paper is organized as follows. First, the elements of the model-based regulatory approach to human factors and human performance are presented. Then, an example of this approach is explained for a specific regulatory review area. After a discussion of the generality of this type of approach, the potential for improving regulatory approaches will be discussed.

II. Model-Based Regulation: A New Way To Conceptualize A Regulatory Approach

At its heart, a model-based regulatory approach relies on comparing an idealized model (e.g., model of a process) against the actual situation (i.e., how the process was actually defined by the licensee); models can also be used to assess implementation of processes. Models can take a number of forms, depending on the aim of the regulatory activity. In this section, we examine a few models of particular interest.

As a regulatory entity, the CNSC can be seen as pursuing a set of goals, with the top goal being to ensure compliance with the objectives of Canada's Nuclear Safety and Control Act (NSCA, 1997). Using this as a starting point, it is possible to draw a hierarchy of goals and sub-goals, with the latter contributing to the achievement of the former, as shown in the Figure 1.

In this Figure, the overall goal is to achieve the objective defined in the Act; this goal can be broken down into sub-goals, one of which is to ensure that proper account is taken of human factors by licensees. In the domain covered by this paper, this sub-goal is linked to a regulatory policy on human factors which states that the CNSC will evaluate the measures proposed and the measures implemented by licensees to address human factors (CNSC, 2000). The dotted lines and boxes imply that numerous other sub-goals may also be pursued to achieve the top goal or even sub-goals.

This type of model can be derived using a technique known as FAST (Function Analysis Systems Technique). FAST provides a systematic means to identify the sub-goals required to achieve higher level goals, and conversely, to identify the higher level goals that can be achieved through the achievement of lower level sub-goals (Bytheway, 1965). Briefly, FAST relies on a systematic and recursive questioning of "how" to identify sub-goals for a given goal, and of "why" to ensure that a sub-goal is effectively linked to its assigned parent goal.

While this first type of model, if constructed correctly, helps to identify all of the goals required to achieve a given purpose, it is not particularly well suited for assessing process definition and implementation. It is thus useful to expand our set of models to assess those activities. The following model, which is related to the previous one, shows explicitly the separation between process and implementation. Models for this purpose exist for most engineering endeavors under the form of lifecycle. A common lifecycle in high integrity environments is the waterfall model of which several depictions can be made. For the purpose of this paper, a simple waterfall model is shown in Figure 2.

It can be argued that this model represents the lifecycle used by a typical Canadian nuclear facility to identify the requirements, and to design and implement a process that contributes to fulfilling one of its operational needs. Dark triangles show CNSC review activities (CNSC review may occur either at the end of a phase, or once the lifecycle is about to be, or has been, implemented). Typical components of this lifecycle are as follows:

- The licensee carries out an analysis that will define the

1 Canadian Nuclear Safety Commission, Ottawa, ON.

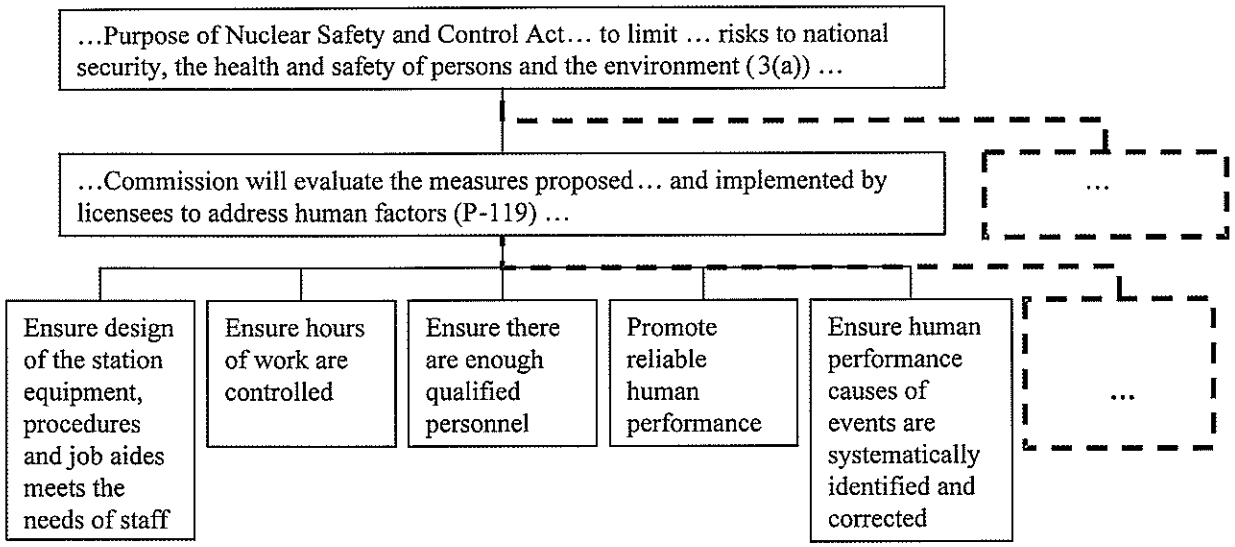

Figure 1: Goal-based Regulatory Model.

basis for the process to be designed. The purpose of the CNSC review is to ensure the adequacy of the basis for licensee processes.

- Once the analysis is complete, the licensee will design and develop a process, consisting of policies, procedures, instructions, etc. The licensee will also ensure that the designed process corresponds to the needs identified in the analysis phase (an activity normally called "Verification" in lifecycle parlance). The CNSC review will also aim at ensuring that processes match the analysis that served as the basis; however, the CNSC review is not meant to replace the licensee's verification activities.
- After the design and development of the process are complete, the licensee will implement the process. At that point, the focus of the CNSC review is to ensure that the process is implemented as designed (e.g., in conformance with station's policies and procedures).
- After implementation, the licensee will normally monitor the process' and implementation's performance to ensure that the operational need is met; in lifecycle parlance, this is normally called "Validation". After implementation, CNSC staff reviews station performance to ensure ongoing adequacy of the basis for the station's processes.

It is possible to express the CNSC's review methods and techniques in terms of models as well.

For example, a regulatory document and the set of derived objectives and criteria used to review a particular regulatory aspect are in fact models of what is expected. In a similar way, a requirement document constitutes a model of the intent that a given design must satisfy without going as far as specifying how to satisfy the intent (which constitutes design, or equivalently, a prescriptive regulatory stand).

This lifecycle model applies to most licensees' processes (e.g., all of the CNSC review areas for human factors and human performance, training, procedure development, etc.) It is actually difficult to see which process would not be covered by this kind of lifecycle. To make things more concrete, the next section will describe an example for minimum shift complement staffing.

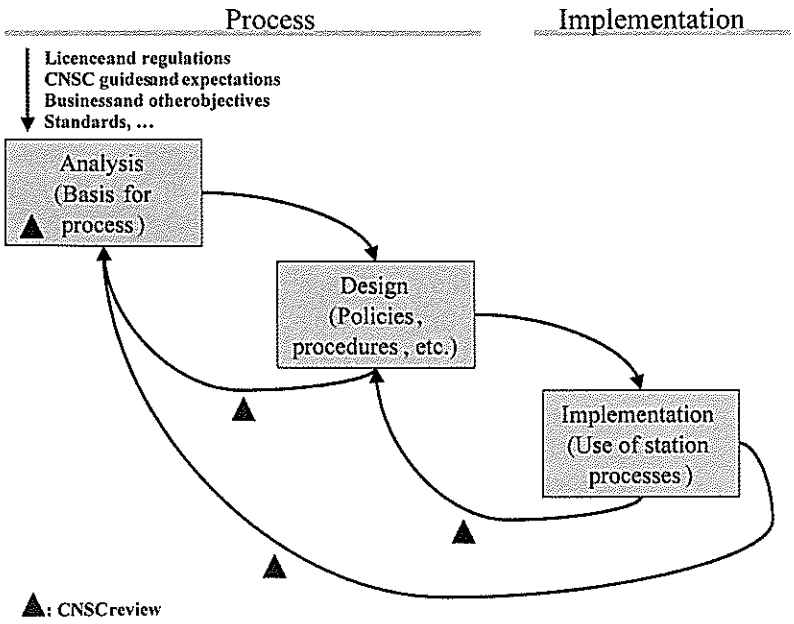

Figure 2: Model of Process and Implementation.

III. Example Of A Model-based Approach For Minimum Shift Complement Staffing

A cornerstone supporting excellence in human performance is ensuring adequate staffing. For this reason, licensees are required to "ensure the presence of a sufficient number of qualified work-

ers to carry on the licensed activity safely" (GNSC, 2000). To comply with this requirement, licensees must demonstrate that:

(a) the engineering and technically based skills that are necessary to support safe operation of the facility are available and will be available into the future, and

(b) the facility is always staffed with a sufficient number of people who are qualified to deal with the most resource intensive conditions (minimum shift complement).

Figure 3 shows the specific application of the generic model shown in Figure 2.

For this example, the CNSC's activities have included:

- An examination of the basis (e.g., task analysis, validation exercises) for the minimum shift complement. This basis provides evidence that there are sufficient qualified staff in the facility to deal with the most resource intensive worst case conditions.
- A review of the shift complement procedures to ensure that they match the analysis.
- Compliance activities to verify that licensees have processes in place to ensure that minimum complement staff are scheduled and are on-site.
- Station performance review to ensure ongoing adequacy of the basis for the station's processes.

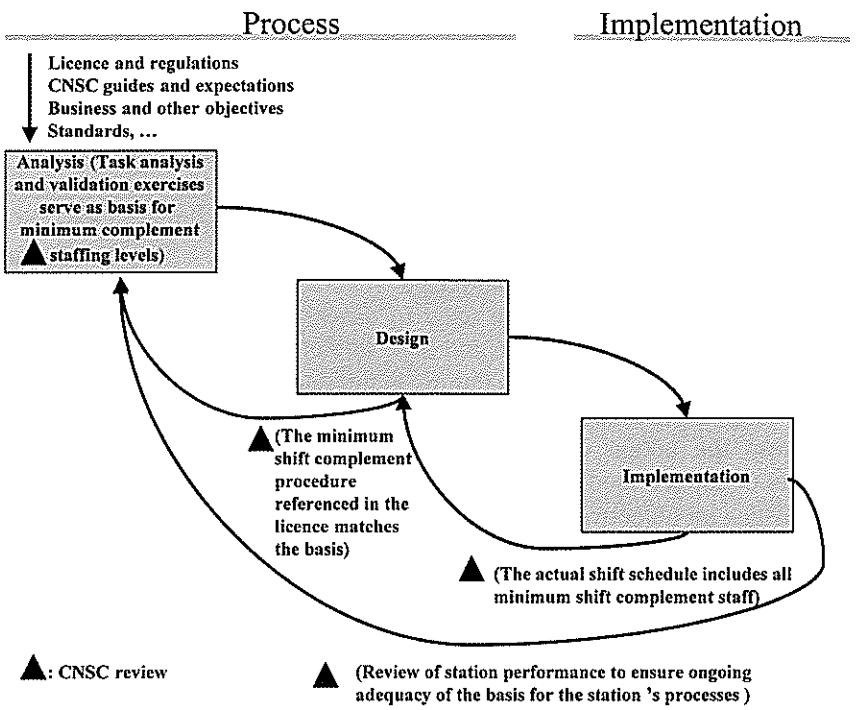

Figure 3: Example of Process and Implementation Modeling for Minimum Shift Complement.

IV. Potential For Improving Regulatory Activities

One of the reasons for adopting a model-based conceptualization of regulatory activities is to identify potential improvements in the regulatory work. There are many ways to do this:

- Examine the model and, provided that the model is a good depiction of reality, use results from the reviews to identify and resolve issues. This is what is currently done during regular regulatory activities.
- Examine the model and attempt to identify critical points based on experience gained generically for the kind of model used.

Both approaches have merit and should, generally, be pursued. However, if one were to capitalize on knowledge and experience drawn from other areas, then particular attention could be paid to the second point - attempting to identify critical points based on generic experience for the model used. In the particular case of the waterfall model, experience has shown that most problems (and costs, even those that are not immediately relevant for regulatory purposes) can be traced back to deficiencies in the analysis phase (Cooling, 1991). It could be argued that this experience is irrelevant since it was gained in another domain, that is, the design of real-time systems. A counter-argument, however, is designing a process is analogous to designing a system, and lessons learned in the former might bear some relevance for the latter. This, at the very least, could serve to stimulate some thinking into how to ensure that process design and its regulation can be improved.

Another area where potential improvements can be found lies in the validation loop. While the waterfall lifecycle tends to be a one-shot event in other design activities, its use for designing and implementing processes in support of operational needs is normally spread over a long period of time, thus enabling a continuous process improvement to take place. The area for improvement is thus to identify relevant performance indicators that can be used by the regulatory authority to enhance safety throughout the duration of the life of the defined process.

A last example of an opportunity for improvement is to use the goal-based model to ensure that all sub-goals relevant to safety have been identified and are subjected to appropriate regulatory scrutiny. To this end, the goal-based model from Figure 1 is an appropriate tool and would support the systematic identification of review areas that warrant regulatory scrutiny. This idea is not new and has already been used by the industry on a different scale. Symptom-based procedures are an example of a breakdown of a goal (maintain safety) into sub-goals (control, cool, contain), and sub-sub-goals (e.g., maintain boiler pressure and level). Scaling up those kinds of goal-based models would have useful regulatory implications.

V. Conclusion

The CNSC has a mandate to evaluate measures implemented by licensees to address human factors and to determine whether these measures provide for protection of the environment and the health and safety of persons. Nuclear facilities are expected to ensure processes are in place to address the needs of workers and to monitor the adequacy of these processes.

This paper identifies a goal-based regulatory model and a waterfall model that are used to assess processes supporting human performance and their implementation.

If one has a model of how something is intended to work, ideally or as close to ideal as reasonable, it is then possible to assess the actual versus expected performance. The benefits of using a model as reference are many:

- Provides an objective basis for regulatory oversight.
- Allows one to identify an unfavorable trend before a hard limit is reached.
- Provides a unified framework to regulatory work.

A conceptualization of regulatory activities in terms of models also eases the identification of areas for improvement. Nuclear facilities are encouraged to apply a model-based approach when reviewing the adequacy of processes in place that support excellence in human performance.

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26th CNS Annual Conference, June 2005

EPR Meeting International Safety Standards With Margin

By Stephen M. Mazurkiewicz[1] and Joerg Brauns, Joreg Blombach[2]

Introduction

The EPR provides technology that offers a solution to the market's need for safe, economic power. The EPR was originally developed through a joint effort between Framatome ANP and Siemens by incorporating the best technological features from the French and German nuclear reactor fleets into a cost-competitive product capable of international licensing. As such, the EPR is a global product with commercial units currently being built in Finland at the Olkiluoto site, and planned for France, at the Flamanville site. Framatome ANP has recently proposed four EPR units to China in response to a request for vendor bids. In addition, Framatome ANP has announced their intent to pursue design certification with the United States Nuclear Regulatory Commission (NRC).

This paper discusses how EPR's innovative safety philosophy ensures compliance with international safety standards for advanced light-water reactors (ALWRs).

General Plant Description

The EPR, an evolutionary pressurized water reactor (PWR), incorporates proven technology within an optimized configuration. The plant's key features of the plant are discussed below.

Reactor

The EPR is an optimized thermal fission reactor founded on commercial plant technology.

Reactor Core

The EPR core contains 241 fuel assemblies to produce a thermal power of 4300-4500 MWth (basic design work conducted for 4900 MWth). Both the coolant and moderator are light-water at a normal operating pressure of 2250-psia. The vessel internals of the EPR are similar to those of conventional PWRs with the exception of a heavy reflector that replaces the baffle plates around the core to improve neutron economy (Figure 1).

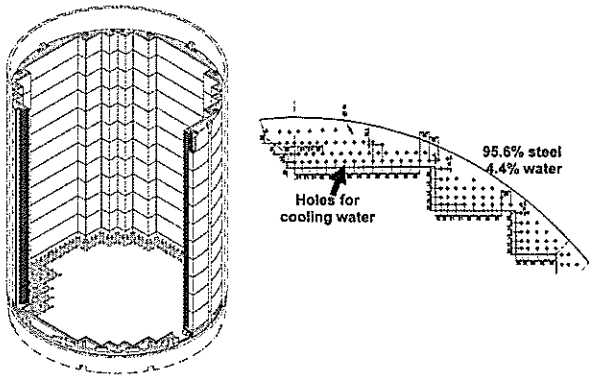

Figure 1. Configuration of the Heavy Reflector

The core consists of fuel rods containing UO2 enriched up to 5%, and can operate with a cycle length up to 24 months. In addition, the core can incorporate mixed-oxide (MOX) fuel as desired (up to 100%). Burnable absorbers (gadolinium) are used to provide global reactivity control and optimize radial power distributions. The power density is lower than typical PWRs, with increased DNB (departure from nucleate boiling) margin during both normal operations and transient conditions. A differentiating feature of the EPR core is the use of unrodded guide thimbles as the location for core instrumentation.

Reactivity Control Systems

Reactivity control in the EPR is similar to current PWRs. Enriched boron concentrations in the primary coolant are varied to control slow reactivity changes. Gadolinium neutron absorbers, in the form of integral burnable fuel rods, establish the derived initial reactivity and power distribution. Rod control cluster assemblies (RCCAs) are used to control rapid changes in reactivity. Each RCCA consists of a group of 24 individual rods, each containing Ag-Id-Cd in the lower portion of the rod and B4C in the upper portion. Load follow operations are performed through a combination of rod movement and changes in boron concentration.

Primary Systems

The EPR employs a primary system based on existing PWR technology.

Reactor Coolant System

The reactor coolant system (RCS) of the EPR is based on a proven configuration seen in operating PWRs (Figure 2).

The EPR is a four-loop plant with an increase in the free volume of primary system components to provide prolonged grace periods during many transients. The RCS configuration includes a reactor pressure vessel (RPV), a pressurizer, four steam generators, four reactor coolant pumps (RCPs), four hot legs, four cross-over legs, and four cold legs.

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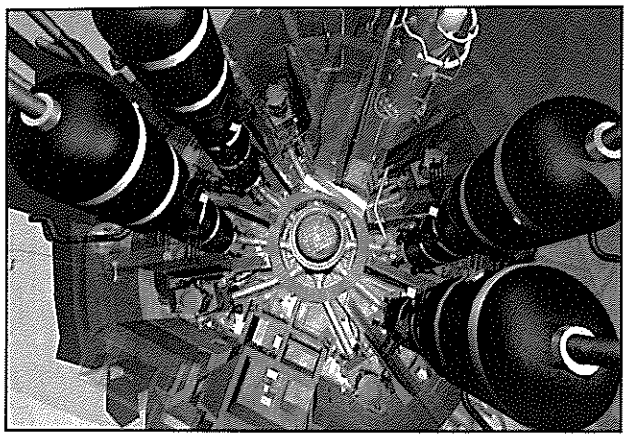


Figure 2: Configuration of Reactor Coolant System

Reactor Pressure Vessel

The RPV is a cylindrical vessel, with a welded hemispherical bottom head and a removable, flanged hemispherical upper head. The EPR RPV is approximately 42 foot tall and 192 inches in diameter. The RPV head includes 89 nozzles for CRDMs, a center nozzle for a temperature probe, and 16 nozzles for core instrumentation. There are no penetrations in the bottom of the vessel.

Steam Generators

The EPR uses recirculating steam generators (RSGs) to produce saturated steam. The four RSGs produce 1130 psia steam at a rate of 19.1x106 lb per hour. The axial economizer is a key differentiation between the EPR RSGs and those of a conventional RSG. By adding a double wrapper in the cold leg of the downcomer and a secondary side divider plate, an approximately 30% equivalent gain of heat transfer performance can be obtained.

Primary Coolant Circulation

The RCPs are vertical, single-stage, mixed-flow pumps located between the cross-over and cold legs of each loop. The RCPs use an optimized mechanical shaft seal system that consists of three seals arranged in series with a stationary seal. The stationary seal creates a sealing surface ensuring shaft tightness when the pump is at rest.

Safety Systems

Because the EPR is based on proven technology, the safety scheme relies on active systems powered by an AC power system.

Containment Systems

The EPR containment is a double-shell structure separated by an annular region (Figure 3).

The inner containment shell is a pre-stressed concrete structure with a steel liner. The outer shell is a reinforced concrete structure designed to protect against external hazards, including a direct hit from a large commercial aircraft.

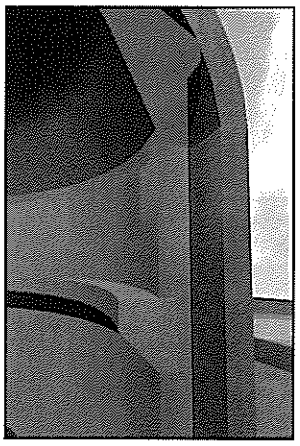


Figure 3: Containment System

The annulus is maintained at sub-atmospheric pressure to collect and filter potential leaks before release to the environment.

Containment Heat Removal

The containment does not rely on active systems to ensure short-term pressure and temperature control. In design basis accident (DBA) conditions, containment heat removal is ensured by the low head safety injection (LHSI)/RHR heat exchanger

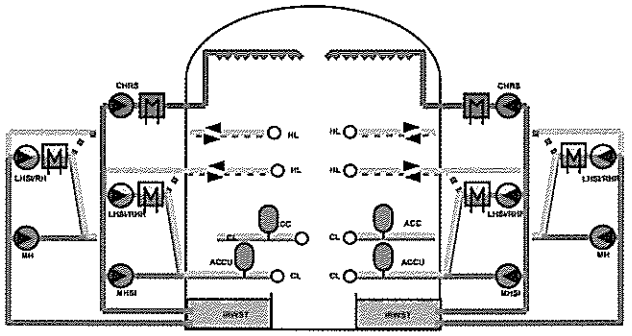


Figure 4: EPR Safety Injection Systems

(Figure 4).

Under design basis conditions, LHSI draws water from the in-containment refueling water storage tank (IRWST) and rejects the containment heat to the plant cooling water systems through the LHSI/RHR heat exchanger before being injected back into the RCS. Operation in this mode ensures that the pressure within containment can be reduced 50% within four hours. Nonetheless, the EPR also includes a containment heat removal system (CHRS) to ensure containment cooling in response to severe accidents. The CHRS cools the IRWST and spreading area in addition to providing the ability to spray the containment atmosphere.

Hydrogen Control

Containment hydrogen control in the EPR is ensured by use of 41 large and six small passive autocatalytic recombiners (PARs) designed to ensure that the global atmospheric hydrogen concentration is below 10%. The containment structure can withstand the resultant pressure from a hydrogen deflagration and is designed to promote atmospheric mixing.

Safety Injection Systems

EPR safety injection is performed by four 100% active trains of medium head safety injection (MHSI) and LHSI augmented

by four accumulators. The active safety injection systems draw water from the IRWST and injects it into the cold leg of each RCS loop. The MHSI system operates at a pressure lower then the main steam safety valve set-points to ensure that, in the event of a steam generator tube rupture (SGTR), RCS inventory is not released directly to the environment. The LHSI system can perform a safety injection function, as well as RHR and containment cooling functions during DBAs.

Residual Heat Removal

The RHR system in the EPR is combined with the LHSI system to reject residual heat to the plant cooling water systems. The RHR system takes suction from the hot leg of each RCS loop and passes the reactor coolant through a heat exchanger before being injected back into the cold leg.

Reactor Coolant Pressure Control

To prevent over-pressure of the primary system, the EPR includes three SRVs connected to the top of the pressurizer that discharge to spargers inside a relief tank protected by two rupture disks. The EPR also includes dedicated valves to ensure depressurization in the event of a severe accident (Figure 5).

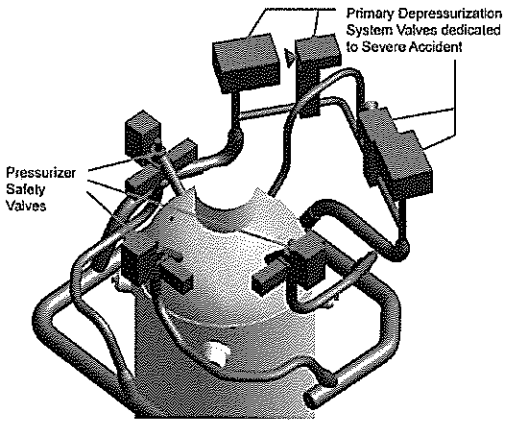


Figure 5: EPR Depressurization Valves

Severe Accident Mitigation

In the event of a severe core damage accident, corium stabilization is based on spreading the molten fuel over an 1830 ft2 surface (core catcher) and cooling it with water passively drained from the IRWST (Figure 6).

The molten core debris (corium) is initially retained in the reactor cavity to equalize the spectrum of melt states and to make spreading and subsequent stabilization independent of certain uncertainties. After temporary retention, the accumulated corium will relocate into the lateral spreading compartment where the arriving melt triggers the passive flow of water and cools the melt from the top and bottom.

Electric Power Systems

As the EPR relies upon active safety systems, electric power systems are optimized versions of the proven designs employed in current nuclear plants.

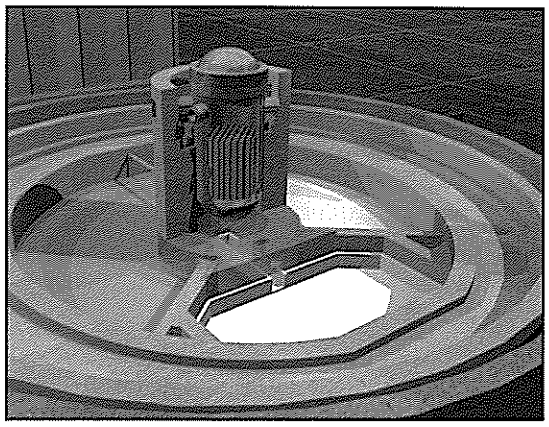


Figure 6: IRWST and Core Spreading Area

On-site AC Power Systems

The EPR includes four 100% safety-related diesel generators capable of supporting reactor shutdown and maintaining it in a safe shutdown condition. The EPR also includes two smaller, non-safety diesels to power critical plant loads during station blackouts.

On-site DC Power Systems

The DC power system is consistent with those of conventional operating plants. The EPR uses safety-related station batteries with a two-hour capacity to supply critical loads in the event of a short-term loss of AC power. In addition, the EPR includes two sets of dedicated batteries to support the plant's severe accident measures with a 12-hour capacity.

Plant Development

The EPR is a global product with a safety philosophy and regulatory basis that ensures an ability to license the plant in a number of regulatory environments.

Developmental History

The storied history of the EPR began in the late 1980's when Framatome ANP and Siemens formed a partnership to develop a next generation PWR. In April 1989, Framatome ANP and Siemens founded a joint subsidiary, Nuclear Power International (NPI), with a mission to establish a common PWR product capable of addressing the market needs and regulatory requirements of the French and German regions. In 1991, Electricité de France (EdF) and a number of major German utilities joined the effort. Throughout the mid- to late-1990s, the basic design of the EPR was completed and a number of optimization evaluations were performed. In 2002, a consortium led by Framatome ANP and Siemens offered the EPR to the Finnish utility, TVO (Teollisuuden Voima Oy), as the third unit at the Olkiluoto site. In 2003, TVO announced that they had contracted the Framatome

ANP-Siemens consortium to build the world's first EPR. In 2004, EdF announced their decision to build a commercial EPR unit the Flamanville site in France. Framatome ANP has recently proposed four EPR units to China in response to a request for vendor bids as well as announced their intentions to pursue design certification in the United States. Furthermore, exploratory discussions with Canadian regulatory authorities are currently underway.

Licensing Basis

One of the major goals of the EPR development was to develop a product that was capable of being licensed in France and Germany. In this context the French and German safety authorities - the DSIN (French government's reactor safety agency) and the BMU (Federal Minister of Environment, Nature Protection and Reactor Safety) - extended their cooperative efforts related to the existing fleet of plants to participate in the development of a common safety approach for future designs. As a result of this effort, a German French Directorate (DFD) was founded at the ministry level, through which the general safety requirements for new reactor technology were established. The technical advisory groups of both France and Germany - GPR (Groupe Permanent Réacteur) and RSK (Reaktor-Sicherheits-Kommission) - established a common set of rules and regulations for new plant development by converging the French and German licensing requirements. These common rules were promulgated by safety experts of each organization through joint meetings and working groups with initial results published in July 1993 [1]. These common rules were used in the development of the EPR design.

Safety Requirements

As part of their regulatory efforts, the DFD issued a clear set of guidelines regarding their expectations for the next generation of nuclear plants in France and Germany. These top level regulatory expectations included:

- Development of an evolutionary design in order to maximize the benefit and experience gained from the current generation of nuclear plants,
- Provide significant safety improvements in the base plant technology by addressing both prevention (i.e., reduction in frequency of core damage) and mitigation (improved radionuclide retention capability) of severe accident conditions, and
- Improve the operational conditions of the plant in the area of radiation protection, maintenance and human errors.

Based on these DFD expectations, the EPR consortium submitted a report documenting the key safety provisions of the EPR. A review of this document resulted in, the DFD emphasizing the following topics for regulatory compliance:

- Protection against external events,
- Severe accident and containment response,
- Integrity of the primary system,
- Radiological consequences of DBAs and select beyond design basis events, and
- Probabilistic risk assessment of safeguard systems.

The DFD's position on these topics was provided as a second regulatory position paper in January 1995. This work has culminated in the EPR Technical Guidelines, which summarizes the requirements to be followed by the next generation PWR.

Technical Codes

The development of a nuclear power plant traditionally implies that a full set of codes and standards exists that define the rules to which to design plant equipment. In the past, both France and Germany have separately developed strong nuclear programs, each relying on their own construction rules. As the objective of the EPR development was the establishment of a common product, a common set of codes and standards was also required. This necessitated a significant technical exchange between experts from both countries to converge upon a common set of codes and standards. These new design rules are referred to as EPR Technical Codes (ETCs). For the EPR project the following ETCs were developed:

- ETC-S (Safety and Process): ETC-S is a compendium of the main rules used for the design of the Nuclear Island, including the interface with the other parts of the plant. It defines the general safety and functional principles to which systems and equipment must be designed. It also defines the rules used for plant safety assessments and radiological release calculations.
- ETC-M (Mechanical Components): ETC-M is the technical code that governs the design of mechanical components.
- ETC-E (Electrical Equipment): ETC-E addresses general design-related requirements for electrical equipment.
- ETC-I (Instrumentation and Control): ETC-I addresses general requirements for I&C systems and was developed as a separate document although there are many similarities with electrical equipment design and qualification.
- ETC-C (Civil Works): ETC-C follows the framework, methodology and most of the recommendations of EC2 (Eurocode N2) which provides general requirements for concrete structures.
- ETC-F (Fire Protection): The fire protection concept of the Nuclear Island is designed according to the requirements of ETC-F.
- EPR Requirements on Handling Devices: This code governs the design of handling devices (i.e., fuel handling systems, cranes, elevators).
- EPR Requirements on HVAC: This code presents requirement for the design of HVAC systems.

Siting Requirements

The development of a nuclear power plant requires certain site specific characteristics that need to be factored into the plant design (i.e., seismic activity, surrounding industry,

soil consistency, etc.). To support development of the EPR, the plant siting criteria referenced in the European Utility Requirements Document (EUR) [2] was used. The EUR document is a common set of utility requirements to be used in developing the next generation of nuclear plants to be built in Europe. This requirements document was developed through the combined effort of multiple European utilities and is similar to the Utility Requirements Document (URD) developed by EPRI for ALWRs in the United States [3]. A reconciliation of the URD and EUR requirements has been performed and indicate a general consistency between the requirements with differences driven by the geological and regulatory requirements of each region [4].

The site related data used for the design of EPR structures, systems, and components (SSCs) are provided in EUR Volume 2, Chapter 4 "Design Basis," and specifies requirements for external events such as airplane crash, seismic events, and explosion pressure waves.

General Safety Approach

To address regulatory expectations, consortium members established an innovative safety approach to be employed within the EPR concept.

Defense-in-depth

In order to enhance plant safety, a four level defense-in-depth (DID) concept was pursued that focused on enhanced accident prevention and mitigation. This expanded DID philosophy includes the following principles:

- Prevent deviations from normal operation,
- Detect deviations from normal operation and prevent the escalation of such deviations into DBA conditions,
- Control DBAs to ensure the prevention of severe accident challenges, and
- Mitigate the consequences of severe accident challenges to avoid the need for stringent off-site countermeasures.

This 4th level of DID focuses on the preservation of the containment integrity and is not considered within the existing fleet of plants. The EPR DID strategy is implemented by the complementary use of deterministic and probabilistic methods. Additional focus was placed on further improving the accident prevention level within EPR even though the current French and German nuclear reactor fleet already represents a low level of severe accident risk. The method employed within EPR to address each of these levels of DID include:

- The first level of DID is maintained through a combination of conservative design, quality assurance, and surveillance activities to prevent departures from normal plant operation,
- The second level of DID is to incorporate features that prevent and detect any departures from normal plant operation. This level of protection focuses on ensuring the integrity of the fuel cladding and of the Reactor Coolant Pressure Boundary (RCPB) in an effort to prevent accidents,
- The third level of DID is to provide engineered safety features and protection systems that mitigate accidents and prevent their evolution into severe accidents (e.g., LHSI, MHSI, etc.), and
- The fourth level of DID is to preserve the integrity of the containment by controlling severe accidents.

Beyond the traditional deterministic design basis, events with multiple failures and coincident occurrences up to the total loss-of-safety systems are considered on a probabilistic basis to minimize the residual risk of operation. To quantify such a level of risk, the following safety objective was established and is consistent with the International Atomic Energy Agency (IAEA) safety objective:

- Probability of core damage including all internal events and internal and external hazards shall be less than 1x10-5 per reactor year.

Categorization Of Events

To demonstrate the enhanced level of safety and compliance with regulatory expectations, specific sets of licensing basis events were selected and categorized based on the expected frequency of occurrence. These categories include:

- Reactivity and power control,
- Core heat removal, and
- Containment of radioactivity

These events are classified into four Design Basis Conditions (DBCs). The classification in DBCs is done according to their expected frequency of occurrence:

- DBC1: Normal operation,
- DBC2: Anticipated Operation Occurrences,
- DBC3: Infrequent Accidents, and
- DBC4: Limiting Accidents

The DBCs contain events caused by the failure of single component, a single I&C function, a single operator error, or loss of offsite power. Each of these events is defined as follows:

- DBC1 - Normal operation: Operation of a nuclear power plant within specified limits and conditions including shutdown, power operation, heat-up, cool-down, maintenance, testing and refueling.
- DBC2 - Anticipated Operational Occurrences: All operational processes deviating from normal operation that are expected to occur one or more times during the operating life of the plant and which, in view of appropriate design provisions, do not cause any significant damage to items important to safety nor lead to DBC3, DBC4, or design extension conditions (DEC).
- DBC3 - Infrequent Accident: These are postulated initiating events, the frequency of which is so small that they are assumed not to occur during the lifetime of a plant but may reasonably occur in the lifetime of a fleet of plants.

- DBC4 - Limiting Accident: These are postulated initiating events, the frequency of which is so small that they are not expected to occur during the lifetime of a fleet of plants.

In addition to DBCs, two DECs are used to categorize events that are beyond the design basis of the plant. These categories focus on a bi-modal consideration of severe accidents and include:

- DEC A - Prevention of core damage
- DEC B - Prevention of large releases

Ssc Safety Principles

The safety features of the EPR focus on ensuring the containment of radionuclides by protecting various fission product retention barriers. The retention concept considers the sources of radioactivity in the reactor core, spent fuel pool, as well as liquid and gaseous effluent storage systems. Therefore, systems designed for the mitigation of DBC events make use of redundancy or diversity and physical or geographical separation of redundant components to reduce the likelihood of a loss of safety function. These systems and components are inspected and tested regularly to reveal any degradation which might lead to abnormal operating conditions or inadequate safety system performance. Furthermore, these systems and components are designed, constructed and tested according to quality standards commensurate with their importance to safety. The criteria applicable for the design include:

- **Simplicity and Functional Separation**
  - The separation of functions is applied,
  - Contradictory demands on valves in the short term are avoided as a basic principle.
- **Redundancy and Diversity**
  - System configuration is based on postulated failure or unavailability (e.g., single failure, preventive maintenance). As a result, safety systems are arranged in a redundant configuration,
  - Diversity of SSCs was investigated to cope with the risk resulting from common cause failures, and
  - Priority was given to functional diversity instead of equipment diversity.
- **Divisional Separation**
  - The redundant trains of safety systems are arranged in separated divisions. The physical separation is also extended to supporting features such as cooling water, electric power, and I&C and
  - There are no interconnections between divisions (only some normally closed headers) up to the connection to the primary or secondary circuit. In case of the postulated loss of one division, the remaining divisions provide at least one full system capacity (100%) of required system, taking into account additional postulated failures.
- **Sensitivity to Failures**
  - Adequate design margins, automation and grace periods, high reliability of the devices in their expected environment,
  - Protection against common mode failures by design against load cases (e.g. earthquake), and
  - High autonomy allowing long grace periods for operator actions.
- **Enhanced Operation**
  - Address operating concerns within the design phase to simplify and optimize future operation.

Radiation Protection

To ensure public health and safety, each of the plant event categories considered within the design corresponds to specified radiological limits (Table 1) to the environment. The radiological limit for normal operations (DBC1) and anticipated operational occurrences (DBC2) is 0.3 mSv/year (0.03 rem/year), (based on German regulatory requirements) while the limit for DBC3 and DBC4 events is 5 mSv (0.5 rem) effective dose excluding the groundwater path.

Table 2: EPR Limits for Design Conditions

Category	Dose Limit (mSv/year)
DBC1	0.3
DBC2	0.3
DBC3	5
DBC4	5

International Safety Standards

As the base EPR was developed to criteria applicable to the French and German safety authorities, it is recognized that licensing the plant in another country would necessitate compliance with the regulatory standards of that particular nation. With commercial EPR units under development for Finland and France as well as an active bid in China and licensing discussions in the United States and Canada, Framatome ANP has experience reconciling the EPR safety philosophy with the standards of other countries.

Consistency With Finnish Rules

An analysis of the EPR design against the Finnish rules was performed during two feasibility studies conducted between

Table 2: Finnish Limits for Design Conditions

Category	Dose Limit (mSv/year)
DBC1	0.1
DBC2	0.1
DBC3	5
DBC4	5

1998 and 2000. Results of this analysis demonstrated that the EPR design was consistent with the safety principles set forth by the Finnish authorities (STUK) for nuclear power plants. A limited number of adaptations were required within the design to meet specific STUK requirements.

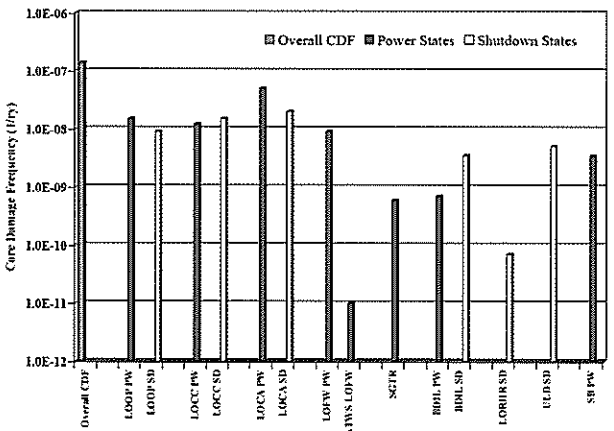
Radiation Protection

The Finnish requirements with respect to radiation protection for each of the EPR DBCs are specified on a per site basis (Table 2). Since the EPR is the third unit at the Olkiluoto site, the limiting dose for normal operation of OL3 is 0.033 mSv/year (0.0033 mrem/year). While this Finnish requirement seems more restrictive, the Finnish dose calculation methodology is not as conservative as the German method. Furthermore, the dose for a specific source term varies as a function of the local conditions of a particular country. The use of the Finnish dose methodology combined with the location and meteorological conditions of the site, demonstrates EPR compliance with Finnish regulations.

Severe accident response is a new category of events for which provisions are included in the EPR design to ensure that extensive environmental counter measures are limited to the plant itself. This objective is expressed in terms of radioactive release limits. For the OL3 plant, the limit of radioactive release into the atmosphere is 100 TBq (2700 Ci) of Cs-137 [5]. Furthermore, it is required that no acute health effects occur within the surrounding population. The combined fallout consisting of nuclides other than cesium isotopes shall not cause in the long term, starting three months from the accident, a hazard greater than would arise from a cesium release corresponding to the above mentioned limit.

Safety Evaluations

Probabilistic targets for Finland are defined in YVL 2.8 (Regulatory Guide) [6], which states that the cumulative frequency of core damage must be lower than 1x10-5 per reactor-year and the mean value of the cumulative frequency for exceeding the limiting release of 100 TBq (2700 Ci) must be below 5x10-7 per reactor-year.



ABBREVIATIONS:

BDIL - Boron Dilution	LOOP - Loss of Offsite Power
LOCA - Loss of Coolant Accident	LORHR – Loss of RHR
LOCC - Loss of Cooling Chain	SB – Secondary Side Preak
LOFW - Loss of Feedwater	SGTR – Steam Generator Tube Rupture
LOOP – Loss of Offsite Power	ULD – Uncontrolled Level Drop

Figure 7: Results of Level I PRA

As part of the original EPR development a Level 1 probabilistic risk assessment (PRA) was performed and later expanded to a Level 2 PRA to support plant licensing in Finland. The results of the Level 1 analysis calculate the mean frequency of core damage for the EPR to be approximately 1.4x10-7 per reactor-year, almost two orders of magnitude below the target value of 1x10-5 per reactor-year. Figure 7 shows the contributors to the overall core damage frequency (CDF). Approximately 62% of the overall CDF (8.8x10-8 per reactor-year) is attributed to internal events during power operation, with the remaining 38% (5.4x10-8 per reactor year) attributed to internal events during shutdown. There is no dominant contributor to CDF, suggesting well-balanced safety systems and functions.

In most sequences, core melt is either not predicted or remains within the RPV. In over 95% of core damage sequences, the containment remains intact resulting in low off-site releases. Only SGTRs are considered as containment bypass events, as the EPR design selections reduce the consequences of interfacing loss of coolant accidents. The probability for core damage coincident with a SGTR is estimated as 9.8x10-10 per reactor-year. Source terms predicted for this condition is a cesium release below 0.01 TBq (0.27 Ci), well below the limiting release of 100 TBq (2700 Ci) and frequency upper bound of 5x10-7 per reactor-year. Furthermore, the CDF from events not included in RC10, but having an impaired containment, is less than 4.4x10-9 per reactor-year; two orders of magnitude lower than the 5x10-7 per reactor-year target.

Technical Codes

Traditional Finnish design rules were not considered in the original development of the ETC; however, it was found that, in general, the Finnish requirements were not more stringent than the ETC. Nonetheless, to support development of the OL3 plant, codes and standards that are traditional for application within Finnish nuclear power plants are used and reconcile with the ETC as follows:

- ETC-S (Safety and Process): For application in OL3, YVL guides supersede the ETC-S criteria.
- ETC-M (Mechanical Components): ETC-M will be integrated into the French RCC-M code which is used in the design of the RCS and supports YVL guides. Section III of the ASME Boiler and Pressure Vessel Code is an alternative consideration for the design of the RCS and would support the YVL guides. ASME Section III is only applied to technical design requirements and not to the licensing procedure or the duties of the authorized inspector and similar agencies. For all the other mechanical equipment, it is intended to maintain the flexibility to apply other industrial codes and standard (ASME, KTA, RCC-M, etc.) in order to ensure a sufficiently large supplier base.
- ETC-E (Electrical Equipment): For application in OL3,

compliance with YVL guides will be ensured.

- ETC-I (Instrumentation and Control): For application in OL3, compliance with YVL guides will be ensured.
- ETC-C (Civil Works): For application in OL3, compliance with ASME rules for the primary containment and Finnish rules will be ensured.
- ETC-F (Fire Protection): The ETC-F is consistent with the specific Finnish guidelines governing fire protection and will be used in OL3.
- EPR Requirements on Handling Devices: This code is based on German (KTA 3902), French and European (FEM 1.001, EN 81-1) rules and will be used in OL3.
- EPR Requirements on HVAC: For application in OL3, requirements will be specified for each HVAC component type according to YVL 5.6, KTA 3601 and specifications (KSD 7051/50, relevant ASME codes, etc.). Quality requirements will be specified according to the component specific safety goals focused on KTA or ASME stipulations.

United States Design Certification

The overall goal of the EPR introduction into the United States market is to build upon the international experience manifest in the overall plant design by demonstrating the consistency with NRC requirements and United States industry codes and standards. While certain changes to the plant design are likely, these changes are expected to be minimal due to the EPR's robust safety philosophy. Obvious changes for United States market introduction include conversion of the electrical design to account for the 60Hz system used in the United States, in addition to conversion of structure, system, and component designs to meet accepted United States dimensional standards.

In converting the international EPR design basis into a stand-alone United States design basis, a detailed reconciliation of the plant versus United States acceptance standards is being performed on a system by system basis to ensure consistency. The overall structure of the United States design remains consistent with its international counterparts. This United States design basis is augmented by other regulatory policies and guidance applicable to deployment of evolutionary PWRs in the United States.

Framatome ANP has performed a preliminary reconciliation of the international EPR design with certain United States requirements governing evolutionary PWRs. Based on that evaluation, it is Framatome ANP's view that the EPR design meets or exceeds safety expectations for new reactor design in the United States.

Framatome ANP has defined the road map to establish that EPR exceeds United States design basis requirements and is currently executing this conversion. This effort focuses on re-establishing the underlying design basis by performing system and component engineering work within the overall framework defined by the international EPR. Engineering work is performed with analysis codes and codes and standards which are accepted in the United States, in a manner consistent with expectations for a design certification effort.

This conversion is expected to result in a virtually identical EPR to those being deployed internationally (in terms of overall architecture, safety, and performance) but with a design basis capable of satisfying requirements necessary for deployment in the United States.

Conclusion

The EPR, originally designed to meet German and French regulatory requirements, also meets Finnish requirements. Furthermore, the robust safety philosophy of the plant suggests consistency with United States requirements and makes the EPR the logical choice to lead an international nuclear renaissance.

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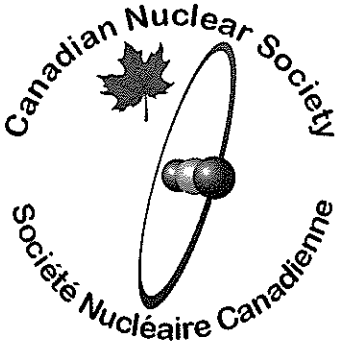

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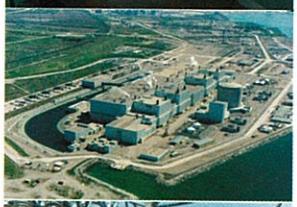

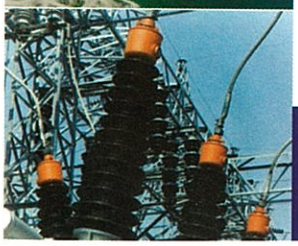

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A.

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GENERAL news

MAPLE - another two years?

From the application by Atomic Energy of Canada Limited to the Canadian Nuclear Safety Commission on August 18, 2005 it can be inferred that it may be another two years before the MAPLE isotope production reactors and the associated New Processing Facility (now jointly described as Dedicated Isotope Facilities or DIF) will be in service.

AECL asked the CNSC to extend the Operating Licences for two years, to November 2007. At the first day of the two-day hearing procedure, August 18, Ken Hedges, AECL vice-president for the DIF, stated that the operating plan for MAPLE 1 is to:

- "operate [MAPLE 1] at 2 kilowatts to establish routine operations and maintenance
- operate at 5 megawatts to perform PCR [power coefficient of reactivity] related tets
- operate at 8 megawatts to test the PCR mitigation features
- produce radiated isotope targets for NPF commissioning
- complete commissioning above 8 megawatts"

The operating plan for MAPLE 2 is "to complete Phase B commissioning up to 500 kilowatts".

The current Operating Licence for MAPLE 1 was issued in 2003. However, commissioning of MAPLE 1 was suspended in June 2003 when it was discovered that the power coefficient of reactivity "was not correctly predicted" [observed to be slightly positive rather than negative]. MAPLE 2 achieved first criticality in October 2003 but was shutdown in January 2004 when a stuck target cluster holder was observed. Reference was made to "expensive" reviews of the power coefficient of reactivity by two national laboratories in the USA.

David Torgerson, AECL senior vice-president, described extensive changes to the management and organization for the project.

Although the CNSC staff recommended granting the licence extension, with a number of caveats, Commission members were clearly not convinced, asking many penetrating questions. Some of those are to be answered at the second day of hearing, scheduled for October 18.

Refurbishment of Point Lepreau Approved

On July 19, 2005, the Premier of New Brunswick announced that the proposed refurbishment of the Point Lepreau nuclear generating station would proceed. He said the decision was based on the need to provide secure, reliable, cost-effective electricity while also protecting the environment. The estimated cost of the project is $1.4 billion.

Atomic Energy of Canada Limited will be the principal contractor for the project. The outage for the refurbishment is scheduled for April 2008 with a target for return to service of September 2009.

New Brunswick had investigated three options regarding the plant: to close it and build a coal-fired unit; lease the plant to Bruce Power; or undertake the refurbishment. The Premier said the third alternative offered the lowest cost and had significant environmental advantages over the first.

CNSC Defers Decision on Financial Guarantee for the Decommissioning of CRL

On July 12, 2005 the Canadian Nuclear Safety Commission (CNSC) announced the adjournment of the hearing on the financial guarantee proposed by Atomic Energy of Canada Limited (AECL) for the decommissioning of its Chalk River Laboratories (CRL), including the MAPLE medical isotope reactors and the New Processing Facility (NPF). This followed public hearings held on September 16, 2004 and May 20, 2005.

The Commission decided to adjourn the hearing until a complete Comprehensive Preliminary Decommissioning Plan in support of the proposed financial guarantee, including decommissioning cost estimates, is available for consideration. The hearing will continue at or before the public hearing that the Commission will hold on the proposed renewal of the CRL site licence in 2006. The specific date(s) for the continuation of the hearing will be announced later in accordance with the CNSC *Rules of Procedure*.

Pickering Unit 1 goes critical

The reactor of Ontario Power Generation's Pickering Unit 1 was restarted on August 2, 2005, for the first time since the unit was laid up in December 1997. OPG reports that commissioning is on schedule and the unit is expected to be in-service in late November.

The refurbishment of the unit has been extensive. This has included detailed inspection of a large sample of the 780 feeder pipes. All heavy water was drained from the heat transport system in February 2004 to permit work on pumps, valves and piping. It was refilled in late May 2005. A pressure test was conducted of the containment building on June 24, 2005.

A worker from OPG's Inspection and Maintenance Services, takes precise measurements of a feeder tube inside Unit 1 feeder cabinets. Tight spaces and radiation protection requirements make the task especially challenging. Photo courtesy of Ontario Power Generation

L-3 MAPPS to build simulator for new Finnish reactor

L-3 MAPPS, formerly CAE, of Saint-Laurent , Quebec, has received a contract for a full-scale simulator for the European Pressurized water Reactor (EPR) being built for the Teollisuuden Voima Oy (TVO) utility in Finland.

The contract, awarded by AREVA Framatome ANP calls for delivery of the simulator in 2007 to allow operators a full year of training before the Olkiluoto 3 unit enters service.

The president of L-3 MAPPS, Rashid Khan commented, "This first-of-a-kind simulator order is analogous to our [CAE] simulator order in 1973 for Pickering A, which ultimately led to our strong position in the power plant simulation market."

L-3 MAPPS has also received orders from Framatome ANP for an engineering simulator for EPR and for upgrades to three existing engineering simulators for the FrenchCP2; DPY and N4 nuclear plant types.

Hawthorne named chairman of WANO

In August 2005 it was announced that Duncan Hawthorne, President and Chief Executive Officer of Bruce Power, has been named Chairman of the World Association of Nuclear Operators (WANO) Atlanta Centre. Hawthorne, who is currently a member of the Atlanta Centre's governing board, will officially begin his two-year term as Chairman in October. Established in 1989 with a co-ordinating centre in London and regional centres in Atlanta, Tokyo, Paris and Moscow, WANO unites nuclear power plant operators around the world. With members in more than 30 countries, its goal is to maximize safety and reliability by exchanging information and encouraging communication, comparison and emulation among its members. "WANO is all about sharing experiences and expertise," Hawthorne said. "Over the years, Bruce Power has benefited greatly from the lessons of other WANO members. During my two-year term as Chairman, I look forward to telling our own story to the rest of the world and bringing even more experiences back home to Bruce Power." Hawthorne has been in the generation business for nearly 30 years, working in nuclear power facilities in Canada, the United States as well as the United Kingdom. A Kincardine resident, he has been an active advocate for the nuclear industry in Canada and abroad. Hawthorne is also currently Chairman of the Canadian Nuclear Association.

Acres International becomes Hatch Acres

As of August 1, 2005, the engineering consulting firm Acres International is now Hatch Acres. However, overseas projects will continue to be executed in the name of Acres International.

Acres was purchased by Hatch Ltd. in June 2004 and is now a wholly owned subsidiary. Hatch Acres has more than 900 employees, with principal offices in Calgary, Niagara Falls and Oakville. Hatch Ltd. is a 50 year-old company with more than 6,000 employees in 80 offices on six continents.

"Definitive" report on Chernobyl issued

The "Chernobyl Forum" issued on September 6, 2005, a digest report, *"Chernobyl's Legacy: Health, Environmental and Socio-Economic Impacts"*. The digest, based on a three-volume, 600-page report which incorporates the work of hundreds of scientists, economists and health experts, assesses the 20-year impact of the largest nuclear accident in history. As of mid-2005, fewer than 50 deaths had been directly attributed to radiation from the disaster, almost all being highly exposed rescue workers, many who died within months of the accident but others who died as late as 2004. The report states, however, that up to four thousand people could eventually die of radiation exposure from the effects of the accident at the Chernobyl nuclear power plant (NPP) accident nearly 20 years ago.

The Forum is made up of eight UN specialized agencies, including the International Atomic Energy Agency (IAEA), World Health Organization (WHO), United Nations Development Programme (UNDP), Food and Agriculture Organization (FAO), United Nations Environment Programme (UNEP), United Nations Office for the Coordination of Humanitarian Affairs (UN-OCHA), United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), and the World Bank, as well as the governments of Belarus, Russia and Ukraine.

Dr. Burton Bennett, chairman of the Chernobyl Forum and an authority on radiation effects, stated, "This was

a very serious accident with major health consequences, especially for thousands of workers exposed in the early days who received very high radiation doses, and for the thousands more stricken with thyroid cancer. By and large, however, we have not found profound negative health impacts to the rest of the population in surrounding areas, nor have we found widespread contamination that would continue to pose a substantial threat to human health, with a few exceptional, restricted areas."

A further agreement between AECL and CNNC

On September 9, 2005 officials from Atomic Energy of Canada Limited (AECL) and the China National Nuclear Corporation (CNNC) signed an Agreement on Nuclear Energy Cooperation at a signing ceremony on Parliament Hill in the presence of Prime Minister Paul Martin and Chinese President Hu.

The Agreement specifies a number of nuclear-related projects on which AECL and CNNC will collaborate. These include joint work on the design of the Advanced CANDU Reactor for China, advanced work on CANDU materials, waste management, CANDU fuel cycles, computerized operations support tools, as well as collaboration in developing advanced technologies including hydrogen production.

The Agreement is an important step in furthering Canada's bilateral relations with China. It is the first deliverable from the Memorandum of Understanding on Nuclear Energy Cooperation that was signed in China in January 2005 during the visit of Prime Minister Martin, International Trade Minister Jim Peterson and Industry Minister David L. Emerson.

CNSC releases responses to question on Convention report

The Canadian Nuclear Safety Commission released, September 12, its 88 page report titled *"Responses to Questions Raised by Peer Review of Canada's Third Report for the Convention on Nuclear Safety"*. It had been tabled at the Third Review Meeting for the Convention in the spring of 2005.

The report provides replies to the several hundred questions raised by representatives of other countries party to the Convention on its initial report.

The report may be viewed on the CNSC website <www.nuclearsafety.gc.ca >

Full environmental assessment not required for NRU

On August 11, 2005 the Canadian Nuclear Safety Commission announced its decision on an environmental assessment of the proposed operation of the NRU reactor to the year 2012. The Commission decided that the project, taking into account the identified mitigation measures, is not likely to cause significant adverse environmental effects.

The screening environmental assessment was prepared in accordance with the requirements of the *Canadian Environmental Assessment Act* (CEAA).

The NRU reactor is located at Atomic Energy of Canada Limited's (AECL) Chalk River Laboratories, Chalk River, Ontario.

The Commission may now proceed, under the *Nuclear Safety and Control Act,* with its consideration of an application from AECL to amend the licence for the Chalk River Laboratories, which if approved, would allow the NRU reactor to operate beyond its currently scheduled shutdown on December 31, 2005.

A one-day hearing for a seven-month extension of the reactor operations (until July 31, 2006) will be held on October 18, 2005. The proposed seven-month extension, if granted, would allow the reactor to continue operating while technical studies are completed in support of AECL's application for a longer-term extension.

Obituary

Don Nazzer

Don Barkley Nazzer, who did much of the mechanical design of ZEEP, the first rector outside the USA, died in Halifax on July 15, 2005.

Born in 1918, Don attended the University of British Columbia. Following graduation in 1941 he worked for the firm of Armstrong Wood in Toronto designing sophisticated weaponry for the armed forces. Subsequently he joined the National Research Council and became attached to the Montreal Laboratory and the Chalk River Nuclear Laboratory. There he was part of the team that designed and constructed ZEEP.

Returning to NRC Ottawa he oversaw the design and construction of the supersonic wind tunnel that was used in the Avro Arrow project.

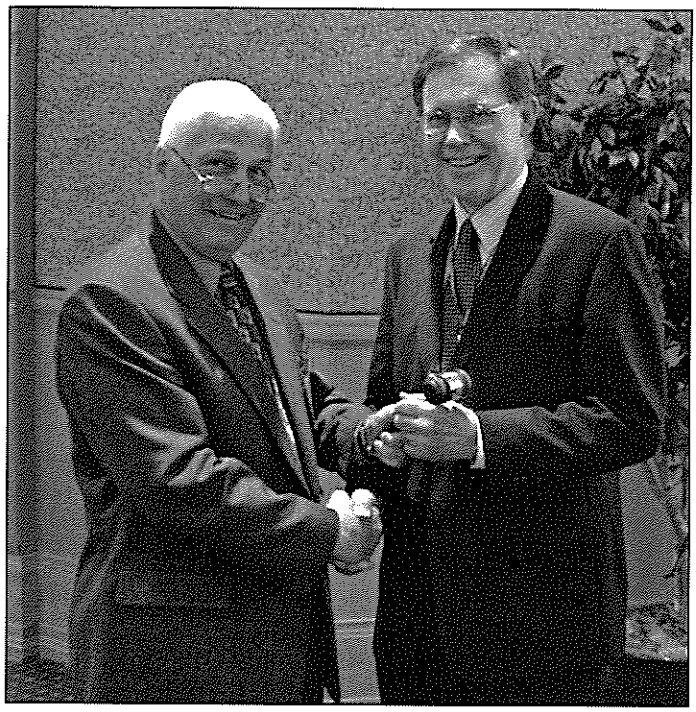
In 1958 he joined the Civilian Atomic Power Department of Canadian General Electric in Peterborough, Ontario. When CGE became involved in the production of heavy water he became part of that project and was responsible for the construction and operation of the plant at Port Tupper, Nova Scotia.

On an invitation from the Nova Scotia government he evaluated the failed Glace Bay heavy water plant and subsequently oversaw its rehabilitation. However, a new government in Nova Scotia shut it down before it operated.

In 1973 he was engaged to do an analysis of the Sydney Steel plant and continued to advise Sysco until he retired in 1980.

CNS news

Annual General Meeting



Outgoing CNS president Bill Schneider (L) passes the traditional gavel to 2005-2006 president John Luxat at the Annual General Meeting, June 13, 2005.

The Annual General Meeting of the Canadian Nuclear Society was held on Monday, June 13, 2005, at the end of the first day of the 26th Annual Conference with approximately 70 members in attendance. This was the eight meeting of the society as an incorporated organization.

2004 - 2005 president Bill Schneider opened the meeting and after acceptance of the minutes of the 2004 AGM gave his report on the year. *(See separate article.)*

Treasurer Ed Hinchley presented his report for the fiscal year 2004, accompanied by that from the auditors. The CNS incurred a deficit of slightly more than $22,000 in 2004 compared to a surplus of about $54,000 in 2003 but the deficit was less than had been anticipated. *(Copies of the Treasurer and Auditor's reports with statements will be sent to all CNS members.)*

Then followed brief reports from the heads of the various divisions, committees and branches and a period for questions or suggestions from the floor. Some members proposed that the CNS should be become active in supporting nuclear power in Ontario, given the procrastination by the current government. Others, however, believed that a professional technical society should not become involved in lobbying.

Past President Jeremy Whitlock presented a list of nominees for the 2005 - 2006 Executive and Council. With no nominations from the floor they were elected by acclamation. *(The revised Council list on the last page reflects the new Council and the subsequent appointments to divisions and committees.)*

The elected officers of Council for 2005 - 2006 are:

President	John Luxat
1st Vice President	Dan Meneley
2nd Vice President	Eric Williams
Secretary	Adriaan Buijs
Treasurer	Jim Harvie
Past President	Bill Schneider

Following the election Bill Schneider passed the traditional gavel to John Luxat who spoke very briefly about the coming year.

Current activities

Education and Communications Committee

World Nuclear University

Mark McIntyre of Atlantic Nuclear Services Ltd. reported at the recent CNS Council Officers' Seminar on his experience having attended the inaugural WNU session this summer.

Canadian Museum of Science & Technology - - International Year of Physics

The ECC has received approval to increase support for the development of the ZEEP reactor dis-

play at the CMST in Ottawa to $4000 as a contribution to WYP2005 activities.

The display was opened in part on September 2 – in time for the September 5 60th Anniversary of ZEEP criticality. Cost increases were encountered as a result of a CNSC requirement to simulate the graphite reflector rather than use the original blocks.

Branch News

Chalk River Branch – *Morgan Brown*

The Chalk River Branch sponsored the four public seminars of the Deep River Science Academy in July. The first featured Jeremy Whitlock who spoke on "Splitting Atoms - Canadian Style." The audience participated in a "ping-pong ball reactor simulation". The Branch recognized two of our three winners of our Second Annual CNS CRB Essay Contest, having first taken them and their parents to dinner. The other speakers were:

- Hilary McCormack, LLB, Crown Attorney for Ottawa-Carleton: "Science and Law - Not so Strange Bedfellows. A Look at DNA Evidence and Crime Solving";
- Dr. Davis Earle, SNO: "Sudbury Neutrino Observatory - Observing the Sun from 2 km Underground"
- Dr. Elizabeth McGregor: ", Ethics & Governance" Who Risks? Who Benefits? Who Decides?"

New Brunswick – *Mark McIntyre*

NB Branch members are pleased with the announcement of the refurbishment of the Point Lepreau NGS.

Officers' Seminar

For the past several years CNS Council has held an "Officers' Seminar" in September to which Branch chairs and Committee chairs who are not elected members of Council are invited, with the object of reviewing the activities of the Society and developing new directions.

The 2005 seminar was held in Hamilton, at McMaster University, the "home" of president John Luxat, on September 9.

Most of the morning was devoted to current Council business. Jeremy Whitlock presented a new logo that includes the name of the Society in English and French. A proposal to hold the 2007 Annual Conference in New Brunswick won general acceptance and will be pursued. On a close vote Council decided not to support a proposal from Women in Nuclear to hold special small gatherings with women of influence with the aim of informing them of nuclear energy.

In the afternoon there were reports from some branches and a discussion of ideas to enhance branch meetings. Bill Schneider presented a revised set of guidelines for branches. Branch chairs were encouraged to use the funds allotted in ways that would attract new members.

Mark McIntyre gave a brief report on his six weeks at the first session of the World Nuclear University, held in Idaho (See separate article.)

CNS President's Report

Annual General Meeting, June 13, 2005

The 2004 - 2005 year has been a very active and, I think, a successful one for CNS. A lot of excellent new program has been achieved during the year and much is in planning for the next year or two. A great many other issues and items of business have been attended to as well - as you will hear as the various Division, Branch and Committee reports are presented.

My major objective as CNS President for 04-05 has been to try to

"make CNS of more value to Operations generally".

And there were a number of major program initiatives to that end. There were major program achievements in other areas as well including;

- the Waste Management, Decontamination and Environmental Degradation Conference just completed on Ottawa in May 8-11 was hugely successful. At this time last year, its organizer and our Environment and Waste Management Division Chair, Michael Stephens had barely enough buy-in from the lead organizations to even think about going ahead; that makes the success that much more remarkable.
- before that, we participated in the CNA Winter Seminar in March
- and had courses on CANDU Safety, Fuel Technology, etc.

Getting back to Operations, which includes operation, maintenance, repair fitness-for-service, condition monitoring and life cycle management work -

- we had three new courses in November and January, all directed at those on the front lines of operation and maintenance. These were the courses on:
  1. Steam Generators Design and Degradation
  2. Eddy Current for Engineers
  3. Chemistry of Preservation and Degradations

These courses, which were organized by the Operation and Maintenance Division, chaired by Peter Gowthorpe, were all were well attended and well received.

- there was also the highly successful, first of a series, February workshop, organized by Dan Meneley, Design and Materials Division Chair on:

"Life Cycle Management Workshop on Heat Transport System Aging"

And there are a lot of new and exciting conferences, courses, workshops and seminars coming up for which the planning was initiated in the 04-05 year.

Organizational Changes

Two new positions have been created within the CNS Executive in addition to thePresident, Past Pres., 1st VP, 2nd VP, Treasurer and Secretary roles. Those positions andthose who currently hold are:

Executive Administrator - Ben Rouben

Financial Administrator - Ken Smith

These positions were created so that all administrative matters within their pre-established terms-of-reference could be handled directly by them. For issues that required Executive or Council decisions, the task of the administrators is to research the matter and formulate an approach for assessment and decision by those bodies. This has been working very well since its inception early in the year.

A Few Other Items

- a CNA-CNS "Summit" was held in Ottawa in May of several executive members from CNA and from CNS for the purpose of reviewing our respective activities and objectives and to co-ordinate those as we go forward.
- like-wise a COG-CNS Summit was held in Toronto in April. A major objective of that discussion was to be aware of each other's workshops and other program so as to avoid conflicts; it is not good to have two events on the same or related subjects near each other in time, even though CNS and COG events have different focus.

These two meetings were very productive in making all of our efforts more effective.

Otherwise, the CNS has vast interests and involvements too numerous to mention here. Many of these will be discussed in the Branch, Division and Committee reports to follow.

Thank you all for the opportunity to serve as CNS President for the 2004-2005 year - it has been busy, interesting and gratifying for me and I trust of some benefit to CNS.

Bill Schneider

A Canadian at WNU *by Mark McIntyre*

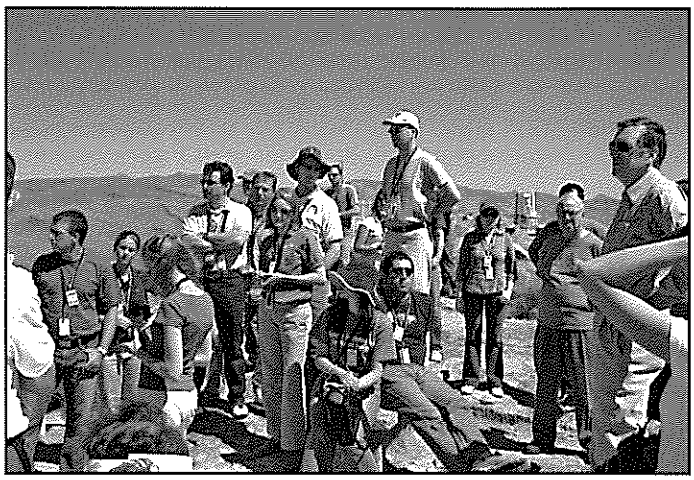
Ed Note: *Mark McIntyre, a very active member of the CNS including being chair of the New Brunswick Branch, was one of five Canadians chosen to asttend the first Summer Institute of the recntly formed (virtual) World Nuclear University. He was partially support by the Society.*

Following is a very brief account of his particiaption in this historic event.

The summer of 2005 was a very exiting time for 77 young(ish) nuclear professionals. It was an opportunity for these representatives from 34 counties to participate in the inaugural World Nuclear University (WNU) Summer Institute. This is a brand new concept, originally devised by leaders at the World Nuclear Association (specifically WNA President John Ritch). The idea has been quickly accepted and endorsed by the major nuclear institutions in the World. The goal of the Summer Institute is to set the scene for the next phase of new nuclear power construction. The WNU recognizes that the training of young nuclear professionals and the development international contacts, must come first.

The location for the inaugural Summer Institute was Idaho Falls, Idaho. The arrangements were organized by a team consisting of Drs. Ed & Deborah Klevens. The local hosts were from the nearby US Department of Energy facility, the Idaho National Laboratory. The home base for the Summer Institute was the Idaho Falls campus of the Idaho State University.

There were 5 Canadians in attendance, Simon Reid from



Hans Blix, former head of the IAEA, is shown with WNU Fellows at the entrance to the Yucca Mountain repository.

Cameco (Port Hope), Tracy Edwards from Bruce Power, Mark McIntyre from Atlantic Nuclear Services, two from AECL Chalk River, Penny Neal & Thierry Joulin. (Also shown in this photo is Dana Pittauerova from the Czech Republic who is looking for work in Canada).

A typical day at the WNU consisted of morning lectures followed by afternoon team building exercises. There were over 40 lecturers on a range of topics which spanned climate change to the world energy crisis to the way to improve operational excellence in nuclear power plants. Lecturers represented organizations from around the world. Some of the highlighted speakers were Zack Pate, first

President of INPO, Geoffrey Ballard of General Hydrogen, Mike Sellman of Nuclear Management Company and US Senator Larry Craig. The high quality of speakers was a drawing card not just for the WNU fellows but also for some of the people from Idaho Falls who were allowed to listen in on some sessions.

Examples of the afternoon team building exercises were paper-and-tin-can bridge building competition, case studies to help firm up theoretical knowledge, public communications role playing and group work that allowed Fellows to discuss and share personal experiences relevant to the topic of the day. As a deliverable for the institute, Fellows were grouped and allowed to choose a final project. My group chose to work on an alternate energy policy for the USA. Our report was 60 pages of applause, where we felt it was due (e.g. nuclear energy incentives, Energy Star program), and scathing criticism, where we felt policy was lacking (e.g. reinforcing the provisions of the grandfather clause of the Clean Air Act which allows the dirtiest of coal plants to continue operating at baseload without new investment in clean coal technology). The timing of this project was impeccable as the real US Energy Policy had just been voted on by the US Congress.

Other group projects investigated impediments to cancer therapy treatment in the developing nations while other group chose to propose an alternate Non-Proliferation Treaty.

The local organizers arranged an excellent social program on weekends that included a trip to Jackson Hole Wyoming for a white water rafting trip on the Snake River, a visit to the Shoshone-Bannock Indian Festival, a tour of the Experimental Breeder Reactor 1, and Yellowstone National Park.

The concluding days of the Summer Institute were held in Las Vegas where the WNU Fellows were allowed to tour Yucca Mountain and discuss support/opposition with local opinion leaders. The concluding banquet at the New York, New York hotel was co-chaired by WNU Chancellor Hans Blix and (by the miracle of impersonation) Elvis Presley.

North American Young Generation Nuclear

Addressing Industry Issues: The NA-YGN Challenges Document

One of the NA-YGN sessions at the 2004 American Nuclear Society Winter Meeting was a brainstorming meeting to determine ways in which employers, professional societies and new(er) employees can deal with issues common to organizations in nuclear industries. The result was the NA-YGN Challenges Document, containing identified challenges, and recommendations for overcoming them.

The session identified five areas for improvement. These areas are:

- Improving Knowledge Conservation and Transfer,
- Improving Recruiting and Retention,
- Improving Leadership and Career Development Opportunities,
- Improving Industry Awareness among Young Professionals, and
- Improving Networking and Interaction Among Young Professionals.

A few of the ideas are listed here; for the whole document, contact Brent Williams at brent.williams@brucepower.com. Also, see the NA-YGN website at www.na-ygn.org.

Actions for Young Professionals:

- Use your organization's mentoring and job shadowing programs. If there aren't any, there's an opportunity for you to set them up.
- Get more training – know your options before you ask
- Participate in conferences and professional society activities
- Share your knowledge with people newer than you
- Ask for rotational assignments – take opportunities that challenge you

Actions for Employers:

- Develop job shadowing, rotation and mentoring programs
- Develop programs to encourage senior staff to transfer knowledge to junior staff
- Include knowledge transfer in job descriptions
- Make knowledge transfer part of building job security, instead of a threat to it
- Introduce perks to average jobs – e.g. support conference attendance, allow travel, have them meet with customers

Actions for Professional Societies:

- Sponsor and develop a handbook with ideas for Knowledge Transfer programs
- Offer incentives to encourage companies to send employees to events
- Engage young professionals and students with session geared towards these groups at professional society conferences
- Provide non-technical development workshops
- Find out why students don't renew their membership

Are you ready for IYNC2006 in Sweden and Finland? <www.iync.org>

NEW MEMBERS / NOUVEAUX MEMBRES

We would like to welcome the following new members, who have joined the CNS in the last few months.

Andrew F. Gibson, UOIT
Kathryn Ashley McGill, UOIT
Chris T.C. Jacobs, UOIT
William Robert Scott, UOIT
Mathieu Richard Gravel, UOIT
KM Safwan Amin, UOIT
Jeffrey Robert Gilchrist, UOIT
Bruno Torcia, UOIT
Jaleh Semmler, AECL
Mohammad Asim Iqbal, UOIT
Derek Ryan James Luth, McMaster University
Orawee Silpsrikul, University of New Brunswick
Vivian Seek-Fong Chew, Kinectrics Inc.
Annmarie Marina Skinner, Kinectrics Inc.
Jackie Kavanagh, MDS Nordion
Stephanie Lynn Stafford, Queen's University
Veronica Gabriana Rosu, Framatome-ANP Canada Ltd.
Colin Jevon Bromley, CANDU Owners Group
Aldo Eugene D'Agostino, Cameco Corporation
Marc-André Charette, MDS Nordion
Jennifer Bellemore, MDS Nordion
Amir Hossein Ramezanpour, UOIT
Mosin Khan, UOIT
Sourena Golesorkhi, UOIT
Robert F. Kozeluh, UOIT
Christian Gordon, UOIT
Areeb Faruqi, UOIT
Tariq Mumtaz Jafri, Simulations Inc.
Ruth MacLeod, UOIT
Mario Désilets, Hydro-Québec
Andrew Khayam Ali, UOIT
Admon Shamoel Ewaz, UOIT
Vikram Sharma, AECL
Alexander Mark Rauket, University of Waterloo
Juliana Andaluza Feteanu, McMaster University
Tatiana Masala, AECL
Bruce Gorham, Atlantic Nuclear Services Ltd.
Benigno Ransenberg, CONUAR S.A.
Thanh To, AECL
Nick Sion, Intercan Technologies
Mark Wittrup, Cameco Corporation
Frank Carchidi, Niagara Energy Products Corp.
Kelly Marie McKeen, Centre for Nuclear Energy Reseacrh
Jennifer Cossaboom, Centre for Nuclear Energy Reseacrh
Terry McCann
Gui Hua Shi, Ryerson University
Francis Walter Barclay

Nous aimerions accueillir chaudement les nouveaux membres suivants, qui ont fait adhésion à la SNC ces derniers mois.

Ronald A. Thomas
Wael Hasan Ahmed, McMaster University
Mikhail Golubev, University of Ottawa
Roger Charles Newman, University of Toronto
Christian Pépin, Hydro-Québec
Liang-Wen (Larry) Lee, University of Toronto
Michelle Ting Zhang, University of Toronto
Kent David Anderson, Unitech Services Group
Linyi Cathy Zheng, University of Toronto
Antonio Chu Chong, University of Toronto
Sindy Leung, University of Toronto
Steve John Sandberg, Rockbestos-Surprenant Cable
Xue Qian Zhang, University of Toronto
Jessie Xu Zhang, University of Toronto
Ying An, University of Waterloo
Anup Kumar Sahoo, University of Waterloo
David P. Clark
Xianxun Yuan, University of Waterloo
Sivakumar Thangavelu, University of New Brunswick
Paul D. Tonner, AECL
Roxana Deaconescu, Bruce Power
Suresh Varma Datla, University of Waterloo
Hannah Haifei Guo, University of Toronto
Divyang K. Masrani, University of Toronto
Lauren J. Krieger, University of Toronto
Meky Fong, University of Toronto
Tom L. Scarborough, Reef Industries, Inc.
Radhey Mohan Mathur, University of Western Ontario
Colin B. Seymour, McMaster University
Graeme D. Doyle, CNS - University of Toronto Branch
Ziqiang Qin, University of Western Ontario
Jun Miyamoto, Carleton University
Jerzy Antoni Szpunar, McGill University
William Motley Saugeen, Safety Services Ltd.
John A. Rollings
Kelvin Hokching Auyeung, UOIT
Bassel Anabtawi, University of Western Ontario
Ragnar Galt Dworschak, AECL
Stephen Farris, Eng., Div. of Curtiss-Wright Flow Control
John Kalanderopoulos, University of Toronto
John (Jake) Westhoven, Framatome ANP Canada Ltd.
Trong Duc Tran, New Brunswick Power Nuclear
Joel William Robinson, AECL
Xiude Lin, Kinectrics Inc.
Simon J. Reid, Cameco Corporation
Adam Joseph Gavey, McMaster University
Aditi Garg, McMaster University

McMaster University
ENGINEERING

TENURE-TRACK FACULTY POSITION
SUSTAINABLE ENERGY ENGINEERING

The Department of Engineering Physics at McMaster University invites applications at all ranks for a tenure-track appointment in the area of sustainable energy technology and system engineering. The successful applicant will be expected to play a leadership role in McMaster's new Centre for Sustainable Energy Systems. This new centre will build upon the university's current research strengths in nuclear engineering, fuel cells, micro gas turbines, thermalhydraulics and other energy engineering fields. Its mandate is to expand upon these activities, with an emphasis on sustainability.

Applicants must have a Ph.D. in Engineering, Applied Physics or a closely related discipline. They should have interest and demonstrated research expertise in technology development and/or systems design, as applied to sustainable energy. In addition to the areas of strength listed above, appropriate research areas include wind and solar energy, advanced combustion, bio-mass, hydrogen, fuel-reforming technologies, energy conservation, and integrated energy systems. The successful applicant will demonstrate a strong commitment to teaching and curriculum development related to sustainable energy. He/she will be expected to teach in the undergraduate Nuclear Engineering and Energy Systems stream of the Department and in our graduate program. The development of a strong, externally funded research program and the ability to relate to industrial practice will be essential. The successful applicant will be required to become registered as a Professional Engineer in the Province of Ontario.

McMaster University is now in the process of establishing the McMaster Innovation Park, which will provide opportunities for engineering scale demonstration projects in energy systems. A demonstrated capability to plan, design and operate such facilities would be an asset. The incumbent will also have an opportunity to participate in the newly established Ontario Centre of Excellence for Energy. For more detailed information on the Departmental activities, please consult our web page at http://engphys.mcmaster.ca.

Applicants should send a letter of application, curriculum vitae, statement of teaching and research interests, a selection of research publications, and the names and addresses of at least three references to:

Dr. Paul Jessop, Chair
Department of Engineering Physics
McMaster University
Hamilton, Ontario, Canada L8S 4L7

This position is available immediately and will remain open until filled. Applications submitted by e-mail will not be accepted.

All qualified candidates are encouraged to apply; however, Canadian Citizens and permanent residents will be given priority. McMaster University is strongly committed to employment equity within its community, and to recruiting a diverse faculty and staff. The University encourages applications from all qualified candidates, including women, members of visible minorities, Aboriginal persons, members of sexual minorities, and persons with disabilities.

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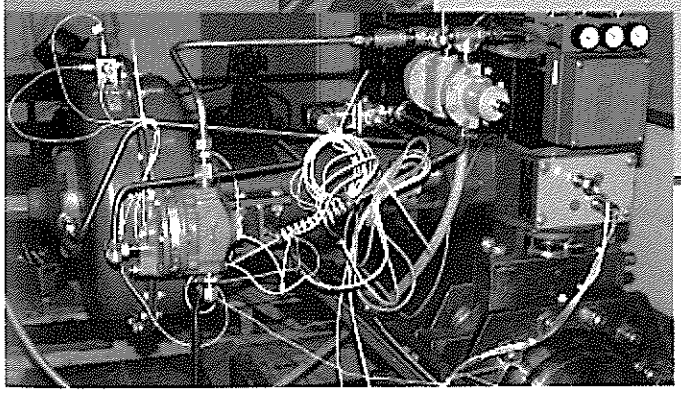
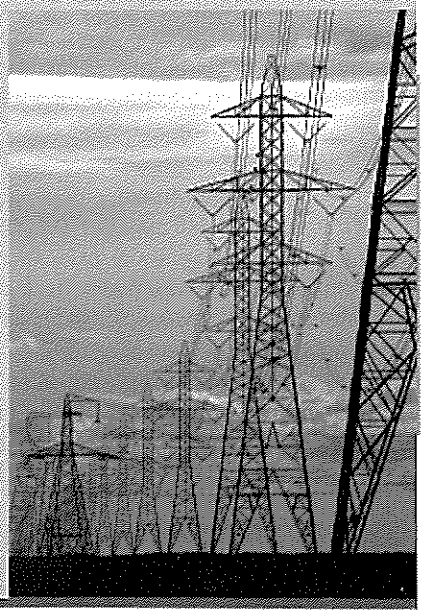
- Safety Procedure and Manuals Development
- Evacuation Planning and Training
- Pre-Start Health and Safety Reviews (PSRs)

Configuration Management and Integration with Plant Systems
- Pre-commissioning and System Turnover
- Utility Information System Update





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Refurbish Thyself

by Jeremy Whitlock

TORONTO - In an unexpected move, the anti-nuclear industry has announced a decision to undergo major refurbishment. The decision follows a lengthy review of the future need for anti-nuclear power in Canada, and the status of energy contrariness in general.

Some anti-nuclear groups have now been operating for 30 years and longer, despite being designed initially for 20-years' usefulness.

"Our whole basis was generational," says Normally Rude, co-founder of the Toronto-based watchdog group Everything is a Problem, "It's sort of a zeitgeist thing. We never intended to be around 30 years later, still saying the same old stuff."

The situation came to a head with the recent decision to refurbish the Pt. Lepreau nuclear station in New Brunswick.

"There's a case where due process was followed to the extreme," says Rude, "They looked at all the options, and still came out in favour of refurbishment. I mean, what could we do? We had nothing."

A news release from Everything is a Problem, shortly after the Pt. Lepreau announcement, attempted to denounce the decision.

"It was ridiculous. We pulled out all the old chestnuts. We even dissed the MAPLE project, for crying out loud. We had nothing relevant to say."

That moment appears to have been the turning point in the anti-nuclear industry's self-review process.

"Our options were simple," says Toady Adams, Executive Director of Everything is a Problem, "We could either shut down the old anti-nuclear groups permanently, or refurbish them to provide a new usefulness for another 20 years."

"Frankly," adds Adams, "I'm too young to retire, so refurbish it is."

But refurbishment, Adams points out, must include completely new ethics and a total mandate overhaul.

"I mean, for decades we've been spoon-feeding the public what they wanted to hear," says Rude, "heck I even advocated roofing the 401 through Toronto with solar panels, if you can believe that."

"Then we started taking money from the gas and oil industry, and guess what? We started selling the virtues of private fossil. We called ourselves 'energy analysts' and 'consumer researchers', seeking global harmony and prosperity. Whatever kept the funds rolling our way. That kind of policy prostitution has to stop."

Rude and Adams also bemoan the years of "stealth fundraising": the initiation and spread of fear in the public consciousness through high-visibility media appearances, with key newspaper editors and radio producers on-board, all stoking the donation machine and channeling funds back to the pockets of Everything is a Problem and other groups.

"And what about government subsidization?" asks Dazed Mumbler, Energy Coordinator for Greenfleece Canada, "How many millions has the anti-nuclear industry taken from the public purse over the years? Just the intervener funding alone - talk about the goose that laid the golden egg. It was like taking candy from a baby during the 'inquiry years' of the Eighties and early Nineties."

"But more than that: how about the support from federal and provincial Ministries, municipal governments, crown corporations like the CBC and CIDA, public agencies like the National Film Board, school boards..."

"Add to this the years of charitable tax status, adjust for inflation over three decades, and you've got a multi-million-dollar public subsidy with bugger-all to show for it. What's our net worth to society?"

It's a bitter pill to swallow, but the anti-nuclear industry seems to be taking its medicine.

"We've milked this as far as it goes", intones Rude soberly, "No more lies. No more exaggerations."

Soft tears glisten in Rude's eyes. "No more telling people that they aren't insured against nuclear accidents. That was wrong."

Where to go from here? It appears that the anti-nuclear industry will simply start doing what it said it was doing all along: provide honest, critical, grass-roots oversight of the nuclear industry.

"Let's face it," explains Adams, "the economy and health of Canadians are just too important. There's simply no sense in opposing the patently obvious anymore."

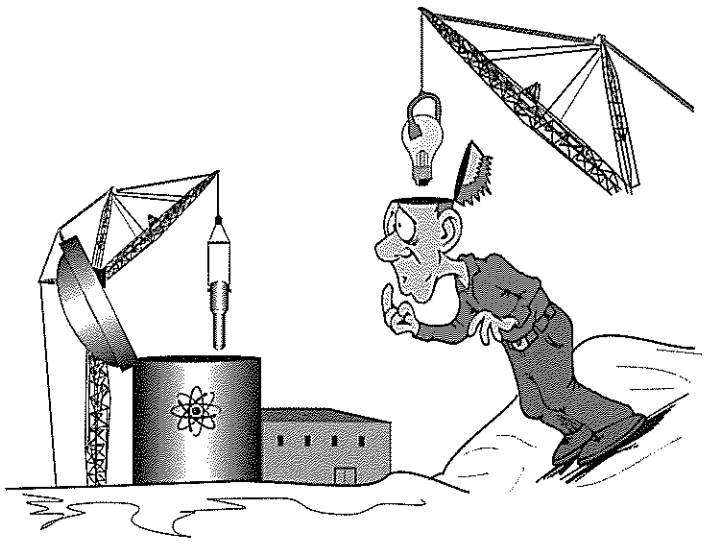
Some inefficient units of the anti-nuclear industry will, inevitably, have to be shut down. Garbled Efforts, spokesman for the Canadian Coalition for Anti-Nuclear Irresponsibility simply shakes his head and whispers, "I'm out of here".

Others, such as Elizabeth Fey of the Ottawa-based Silly Club, are not as resigned to their fate. "I'm going to sue the utilities for $50 billion," she warns, "then I'm going to sue the nuclear industry, then I'm going to sue my so-called compatriots for leaving me in the lurch, and you'd better watch out or I'll sue you too."

In general, however, the future looks bright for responsible power generation, and responsible power criticism, in Canada.

"It's time to do the right thing," Normally Rude sighs with quiet resignation.

"By the way you're not going to print any of this are you?"



CALENDAR

2005

Oct. 2 - 6
NURETH 11 Nuclear Reactor Thermal Hydraulics
Avignon, France
website: www.nureth11.com

Oct. 3 - 7
International Conference on Safety of Radioactive Waste Disposal
Tokyo, Japan
website: www.pub.iaea.org/MTCD Meetings/Meetings2005.asp
email: H.Schmid@iaea.org

Oct. 9 - 13
Global 2005
Tsukaba, Japan
website: www.global2005.org

Oct. 23 - 27
SIEN 2005
Bucharest, Romania
Contact: Mihalela Stiopol
email: mstiopol@nuclearelectrica.ro

Nov. 20 - 22
7th CNS Int'l. Conference on CANDU Maintenance
Toronto, Ontario
Contact: Denise Rouben, CNS
email: cns-snc@on.aibn.com

Dec. 11 - 14
European Nuclear Conference
Versailles, France
website: www.sfcn.fr/enc2005

2006

Feb. 12 - 15
ANS Topical Meetings - 9th Emergency Preparedness & Response - 11th Robotics & Remote Systems
Salt Lake City, Utah
website: www.sharingsolutions.com

Apr. 27, 28
PLIM + PLEX 2006
Paris, France
website: www.neimagazine.com/plex

May 9 - 12
EIC Climate Change Conference 2006
Ottawa, Ontario
website: www.ccc2006.ca

May 31 - June 2
WIN Global
Cambridge, Ontario
Contact: Susan Brissette, Bruce Power
email: susan.brissette@brucepower.com

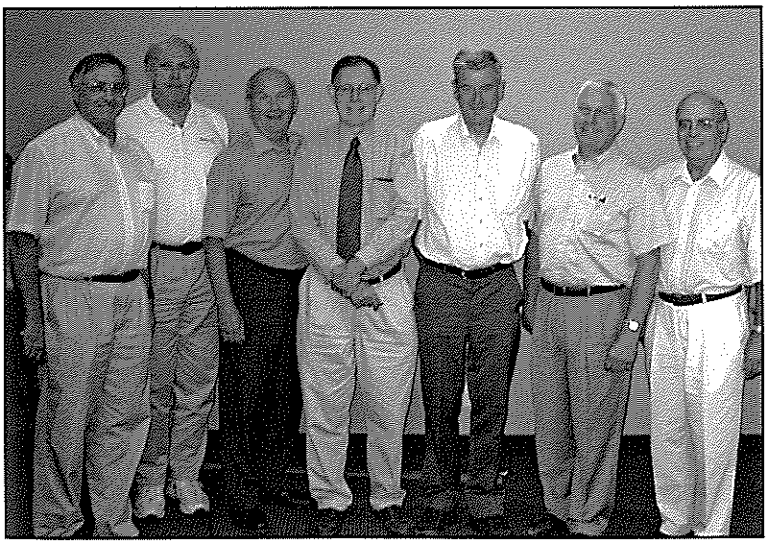
June 4 - 8
ANS Annual Meeting & ICAPP 2006
Reno, Nevada
website: www.ans.org

June 11 - 14
27th CNS Annual Conference & 30th CNS/CNA Student Conference
Toronto, Ontario
website: www.cns-snc.ca

Sept. 10 - 14
Physor - 2006 Physics of Reactors 2006 Advances in Nuclear Analysis and Simulation
Vancouver, British Columbia
website: www.cns-snc.ca/physor2006
email: physor2006@aecl.ca

Oct. 15 - 20
15th Pacific Basin Nuclear Conference
Sydney, Australia
website: www.pbnc2006.com
email: pbnc2006@tourhosts.com.au

Nov. 12 - 16
ANS Winter Meeting
Albuquerque, New Mexico
website: www.ans.org



Shown is the CNS Executive for 2005-2006

Left to right: Ben Rouben, Executive Administrator; Eric Williams, 2nd V.P.; Dan Meneley, 1st V.P.; John Luxat, president; Jim Harvie, treasurer; Bill Schneider, past president; Ken Smith, Financial Administrator. Absent: Adriaan Buijs, secretary.

2005-2006 CNS Council • Conseil de la SNC

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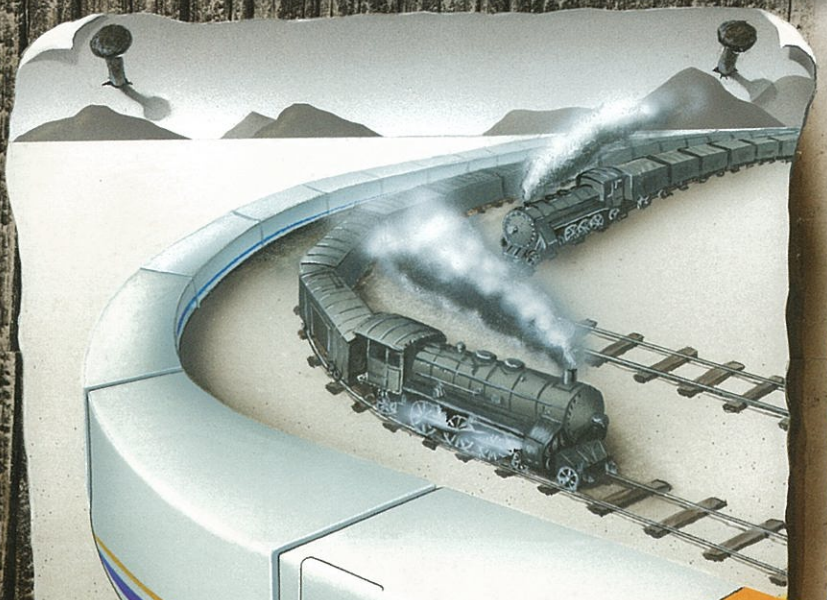

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