CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

JUNE 2008 JUIN VOL. 29, NO. 2

- 29th CNS Annual Conference
- Nuclear Achievement Awards
- W.B. Lewis Lecture
- Refurbishment and New Build

New Build – Have We Got the Right Stuff?

As Ontarians await the decision of Infrastructure Ontario's Request for Proposal for new build, something not seen in Canada in nearly two decades, vendors are scrambling to line up suppliers, designers, operators, cash, and pre-licensing design certification. However, given the Darlington fiasco twenty years ago (nearly ten years late and $10 billion over budget) critics are questioning whether any of the vendors have the ability to keep their promise of delivery on time and within budget. One can argue that the Darlington problems were unique and not likely to arise today as evidenced by AECL's overseas success building its last half-dozen CANDU® reactors on time and within budget. So why worry?

All three vendors in the Ontario bid are proposing first-of-a-kind Generation III reactors. These advanced reactors feature new technology to improve safety, efficiency and cost and provide a 60-year service life. European giant Areva NP has two new GEN III projects of EPR design under construction, one in Finland and another in France. Already, they are over budget and behind schedule. Although part of the cost over-run is attributed to design changes imposed by the Finnish regulator, the major hold-up is delivery of heavy forgings, in particular the reactor vessel. Until recently this year, there were only two companies in the world who have the technology and skilled craftspeople to produce these 500 tonne steel vessels. Both are located in Japan, one of which (Japan Steel) produces traditional Samurai swords. Westinghouse has ordered about 20 heavy forgings for their AP1000 design for new build projects around the world. With a "small" down payment of $100 million, we might get one delivered by 2020. However, the market is expected to respond to this major bottleneck. In May of this year Doosan Heavy Industries in Korea announced its capability to produce new forgings for its Korean APR-1400. Although AECL's ACR-1000 does not rely on these heavy forgings, which is an advantage today, there are problems to be resolved in manufacturing the advanced pressure tubes, which have more stringent material specifications compared to the current CANDU.

New build aside, what about established technology? Refurbishment of government owned Pickering A was a financial disaster and was cancelled after returning only two of the four units to service. Privately owned Bruce Power is refurbishing its Bruce A reactor units 1 and 2, and despite best practices in project management it too is over budget and behind schedule. Although some difficulties were encountered in the removal of the old pressure tubes, the supply of replacement tubes has been problematic. This is not new technology, but after 20 years without orders, the knowledge and skill inherent in the craftspeople that machine and manufacture pressure tubes has diminished and it is taking longer and costing more to produce tubes with the required quality.

The problem facing the world nuclear renaissance is not so much due to new technology, but the loss of human knowledge and skill. We need the highly skilled crafts and trades people who understand the nature of quality control with ever tightening material specifications and tolerances. Those who possess it are retiring and the new generation is on a steep learning curve. The challenge is to retain and strengthen that thread of knowledge and capability whilst managing first-of-a-kind technology. Do we have the right stuff to tackle this challenge?

In This Issue

In case you were worried that your copy of the June Edition of the **CNS Bulletin** was lost in the mail, my apologies – although the delay was intentional so that we could provide coverage of the CNS's main event, the Annual Conference held June 1 – 4, 2008.

The **29th Annual Conference** of the Canadian Nuclear Society attracted a record attendance of over 450 people! This was unexpected and registrations had to be closed two weeks before the event, but this is also a good testament to the growing interest in the Nuclear option for providing our future energy needs. Embedded with this conference was the **32nd CNS/CNA Student Conference**.

Fred Boyd provides an excellent review and commentary of the conference. We have also included a selection of the **plenary papers** where written submissions were made, including "Nuclear Recycle" by W. Hannun, "Pressure Tube Reactors And A Sustainable Energy Future: The Ultra Development Path" by R. Duffey and "Nuclear Regulation and Gen III Reactors" by J. Waddington. In addition to the CNS Conference, **Michael Grey** has kindly reportd on our sister society's 9th Annual Conference of the **Canadian Radiation Protection Association.**

Each year the Canadian Nuclear Society and the Canadian Nuclear Association join forces to honour individuals and groups who have contributed significantly to the Canadian nuclear program. These **Canadian Nuclear Achievement Awards** were presented at the conference and a special section of this Edition includes the results.

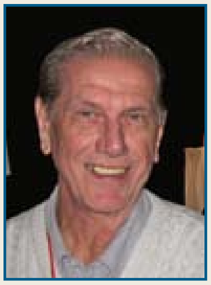
It has been a long-standing tradition of the CNS Bulletin to include the **W. B. Lewis Lecture**. This year **Dr. Eddy Isaacs** of the Alberta Energy Research Institute gave the lecture, "Canada's Oil Sands: Nuclear Power in an Integrated Energy Economy".

More than 100 **technical papers** were presented at the conference, most dealing with issues of ageing management, refurbishment projects, Generation III reactors and siting and environmental assessments. Three of the papers are included in this edition.

Fred Boyd's regular **General News** has some interesting developments and the regular **CNS News** contains a report of the **11th CNS Annual General Meeting**, which attracted over 80 CNS members. Since the president's gavel is handed over at this meeting, we include the remarks of outgoing president **Eric Williams** and in-coming president **Jim Harvie**.

Last but never least, **Jeremy Whitlock** shares his "reality show" wisdom in his satirical view of current events in **Endpoint**.

Comments and letters are always welcome.



Society Affairs

By that title I do not mean the type of affairs found in the tabloids at the exits of supermarkets – although such "affairs" might increase the visibility of the CNS.

Rather, the CNS is experiencing growing pains. While growth is generally good it can bring challenges and the CNS has had several over the past couple of years.

The Society has continued to present successful conferences and courses but these have been planned and executed almost entirely by volunteers. It became apparent to at least some members that this as an unsustainable path. Although membership has grown the number of volunteers has not.

As noted on this page and in (then) president Eric Williams note in the CNS News section of the last issue of this CNS Bulletin, last year's Council empowered a task group of Murray Stewart and Bob Hemming to review the organization and operation of Council and make recommendations. This year's Council (and the membership at large) will be acting on those recommendations and making some significant decisions about the organization over the next few months.

Probably most dramatic is the proposal to hire an Executive Director, initially part-time but expected to become full-time. This will be a significant expense for an organization whose income can be quite variable. Because of the success of recent conferences and courses the CNS' coffers are full, total assets now exceed $800,000, so the Society can afford to go the route of an Executive Director, IF members wish to go that route.

The other financially significant proposal is to employ professional conference organizers to run our major conferences. To date, the annual conferences and most of the topical ones have been organized by volunteer committees of members. Obviously the difference in cost will be significant. Further, there may be a loss of input from those working in the subject area of the conference.

Related to these two major proposals there is, in the view of some of us, a need to revamp how Council operates. This will be especially so if the two proposals above are accepted. Council would then have to become more of a policy board and develop clear objectives, policies and broad plans for execution by the Executive Director, staff and hired organizers. Having gone through such a transformation on a Board of a large social organization I can attest that such a change is not easy.

Now Past-President Eric Williams has been assigned the responsibility to pursue and probably implement the recommendations of the Task Force. He will be working with a Council that has several new members and he has stated that he wants to involve the whole membership of the Society.

So keep your eyes open and, if you already have opinions, send them to Eric and the new executive.

The MAPLE Affair

Again I use the word "affair", but, in this case, in a derogatory sense.

The history of the MAPLE project and its recent collapse is, in my view, the most disheartening event of Canada's long, and until now, very proud nuclear program.

Over a half century ago, with the Second World War behind us and the legacy of the incredible work of the members of the Montreal Laboratory Canada began a major nuclear program focussed strictly on peaceful purposes – the first country to do so.

Despite our small population, we built one of the world's best nuclear research centres and the best research reactors. Then, we pioneered a distinct design of nuclear power reactor using natural uranium so that we would not be tied to the military-based enrichment facilities of other countries. And, developed a design that could be primarily built here.

That evolved into what has been called the CANDU design which is one of just three of the many reactor concepts of the 1950s and 1960s that remains commercially viable.

The curt explanation for the cancellation of the MAPLE project, that "sometimes technical challenges are too great", is totally insufficient. Without a full disclosure of the problems MAPLE will be regarded as one of the poorest planned, worst managed, projects, not just of our nuclear industry but of the country.

I have spent much time in Korea, beginning with their purchases of a PWR and a CANDU in the 1970s, and have observed the growth of their remarkable nuclear program. In the context of the MAPLE program last year I visited their HANARO research reactor. It was designed using the same reactor physics concepts as MAPLE (and the earlier infamous Maple X). It is now one of the best research reactors in the world and, at the same time, produces all of the medical radioisotopes used in Korea.

Do we now buy from them ?

Fred Boyd

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~ Cover Photo ~

Aerial view of the Darlington Site announced for New Build in Ontario. The new reactors will be located east of the existing station.

– Photograph courtesy of OPG

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The Canadian Nuclear Society
480 University Avenue, Suite 200
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Telephone (416) 977-7620
Fax (416) 977-8131
e-mail: cns-snc@on.aibn.com

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

Publisher
Fred Boyd Tel./Fax (613) 592-2256
e-mail: fboyd@sympatico.ca

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2008 CNS Annual Conference

- record attendance at 29th event

by Fred Boyd

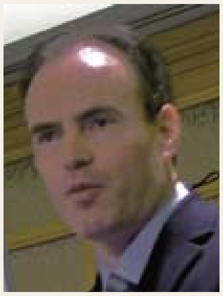
The 29th Annual Conference of the Canadian Nuclear Society (and the embedded 32nd CNS/CNA Student Conference) held in the Marriott Eaton Centre Hotel in downtown Toronto, June 1 – 4, 2008, drew a record attendance of over 450. Interest in the 2008 CNS Annual Conference was so strong that registration had to be cut off two weeks before the event.

Those participating were treated with interesting plenary presentations, almost 100 technical papers, an array of over 30 informative exhibits, two special luncheon speakers and the traditional Canadian Nuclear Achievement Awards banquet.

A highlight was the first public address by Dr. Michael Binder since being appointed President of the Canadian Nuclear Safety Commission on May 9, 2008.

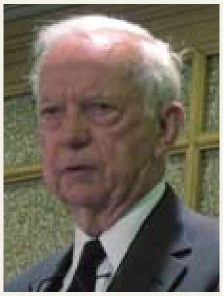
Following the format of the past several years, there was a pre-Conference reception on the Sunday evening, June 1. The pattern of the conference was: plenary sessions (with invited speakers) on the Monday morning, Tuesday afternoon and Wednesday morning; with the alternate afternoons and mornings devoted to parallel sessions of technical papers and parallel student presentations.

The W. B. Lewis invited lecture, sponsored by the Research and Development Panel of Atomic Energy of Canada Limited, was presented at the Monday lunch.



The formal conference began the Monday morning with a plenary session. After a welcome from CNS president **Eric Williams**, Honorary Chair, **Patrick Lamarre**, president of SNC Lavalin Nuclear, officially opened the conference and followed with a short review of the world nuclear scene. Nuclear power has proven to be competitive, he noted, even while providing for its waste and clean-up, which no other industry does. However, he noted, we must maintain the current high level of acceptability by the public.

Although the program showed the first address to be given by the Ontario Minister of Energy, Gerry Phillips, last minute problems precluded that.



The first presentation was by **William Hannum**, formerly with the US Department of Energy, who titled his talk simply as *Nuclear Recycle*. "Sensible recycling of used nuclear fuel will allow nuclear power to satisfy the early dream of environmentally responsible, essentially unlimited, energy at a reasonable cost", he stated. Emphasizing that he was expressing only his own ideas, he argued that recycling is needed if we are to have sufficient fuel for the many nuclear plants anticipated around the world. While acknowledging the concerns about proliferation of military grade plutonium, he still urged building fast reactors and recycling plants. "We need to implement a major diplomatic effort to address the REAL proliferation problems", he stated in closing. *(Hannun's written paper is reprinted in this issue of the* CNS Bulletin.*)*

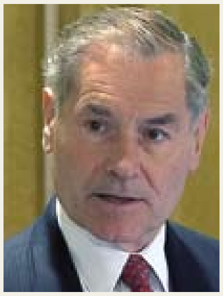
Next was **Romney Duffey**, principal scientist at AECL, whose paper had the long title of *Pressure Tube Reactors and a Sustainable Energy Future: the Ultra Development Path*.

"With expectations of significant expansion in nuclear power programs worldwide and the resultant concerns about uranium availability and price, there is a growing desire to improve resource utilization by extracting more energy from each tonne of mined fissionable material", he stated. Although the focus is on fast spectrum reactors for the distant future, there are compelling reasons to continue to utilize and optimize advanced fuel cycles in pressure tube reactors (PTR) such as CANDU, he said.

PTR reactors can use not only natural and enriched uranium, but also a wide variety of other fuels, he noted. These include:

a) re-cycled uranium into CANDU 6 and ACR;
b) thorium-based fuels with U233 recycle;
c) minor actinides "intermediate burner";
d) MOX fuels in ACR;
e) re-cycled LWR and ACR fuel into current CANDU 6 fleet.

(Duffey's written paper is reprinted in this issue of the CNS Bulletin.*)*



John Waddington, a former Director General of the CNSC (and AECB) addressed the looming regulatory challenges in a presentation titled: *Nuclear Regulation and Gen III Reactors.* The expected growth of nuclear power over the coming decades will not only strain the resources of the industry but will challenge nuclear regulators to develop ways of ensuring even higher levels of safety, he stated. We can and should learn from the aircraft business, he asserted, and the standardization of safety requirements.

While rationally the owner / operator has total responsibility for safety there is a need, he said, to share experience and, in particular, design changes. Despite the fact that the nuclear regulatory agencies of several countries now offer design certificate prior to construction it is likely that there will be changes dictated by local conditions. He referred to a draft document from the International Atomic energy Agency, INSAG 21. *(Waddington's written paper is reprinted in this issue of the* CNS Bulletin.*)*

The last presentation of this first plenary session was by **Marc Rosen**, Dean of Engineering and Applied Science at the University of Ontario Institute of Technology. His topic was *Hydrogen Energy and Sustainability: Overview and the Role of Nuclear Energy.*

After referring to the context of the current energy scene, especially climate change and sustainability, Rosen noted that hydrogen can be used like electricity as a carrier of energy. Hydrogen is not available naturally, it must be extracted from various compounds. He listed the following production processes, all using fossil fuel:

- steam forming of natural gas
- catalytic decomposition of natural gas
- partial oxidation of heavy oil
- coal gasification
- sulphur-iodine thermochemical exchange

Non-fossil sources could be used, especially for the electrical hydrolysis of water. His school, UOIT, has a research program using a Cu-Cl cycle.

The **W. B. Lewis lecture** was presented at the luncheon. This was one of a series begun by Atomic Energy of Canada Limited in 1988 in memory of Dr. W. Bennett Lewis who headed the Chalk River Laboratories from 1946 to 1973 and was a leader in the development of the CANDU nuclear power concept. This year's lecturer was **Dr. Eddy Isaacs**, Executive Director of the Alberta Energy Research Institute. The title of his lecture was: *Canada's Oil Sands: Nuclear Power in an Integrated Energy Economy.*

He began by noting that the Canadian oil sands have emerged as the largest new reserve of oil in the world. Production in 2006 averaged 1.25 million barrels per day and is increasing rapidly. However, to extract the bitumen large amounts of energy and water are required, which result in contaminated tailings ponds, undesirable air emissions including large amounts of greenhouse gases. Nuclear energy promises a more sustainable, less polluting source of energy.

A 2003 study showed that nuclear could be competitive with gas but further studies identified problems of insufficient steam pressure, normal nuclear units too large, and the licensing process as too long and complicated. Nevertheless, Bruce Power has made an initial application to the Canadian Nuclear Safety Commission for a site in the Peace River area.

He summed up the potential for nuclear in the oil sands as:

Advantages:

- no GHG emissions
- improved air quality
- low fuel costs
- natural gas conservation strategy
- Synergy with SMR's and gasification

Challenges

- public confidence in safety
- spent fuel management

- expensive to build, large investor risk

- government support required – policy to lower licensing and financial risks
- capital intensive in an already overheated financial market

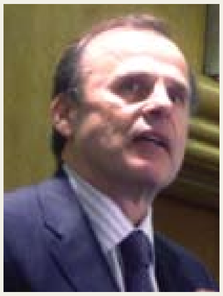
(Isaacs' written paper for the W.B. Lewis Lecture is reprinted in this issue of the CNS Bulletin.*)*

The afternoon saw the first set of five parallel sessions of technical paper and two parallel sessions of student papers. That pattern was repeated on the Tuesday morning and Wednesday afternoon. The following list of session titles provides an indication of the diversity of the technical papers.

- Advanced Reactors
- Plant and Components
- Process Systems
- Thermalhydraulics
- Safety and Licensing
- Hydrogen
- Human Factors
- Physics
- Instrumentation and Control
- Environment and Waste Management
- Plant Operation

Late Monday afternoon there was a special "President's Plenary Session" organized and chaired by 2007 – 2008 CNS President, **Eric Williams**, titled, *Implementing Adaptive Phased Management for Canada's Used Nuclear Fuel.*

"Adaptive Phased Management" is the name given by the Nuclear Waste Management Organization (NWMO) to the process it recommended in late 2005 for the future handling of the spent uranium fuel from Canadian nuclear power plants. That recommendation was formally adopted by the federal government in 2007. There were three speakers.



Frank King, Vice-President, Science and Technology at NWMO, provided a brief review of NWMO and the events leading to its formation in 2002. He noted the decade of studies by AECL on a deep geologic repository concept including the Underground Laboratory near the Pinawa Nuclear Laboratory in Manitoba and the equally long inconclusive review by the "Seaborn" panel.

Three year after its formation the NWMO submitted its report recommending an "Adaptive Phased Management" approach which would involve continuing to store spent fuel at the nuclear stations while further studies are conducted regarding a possible repository. He closed by stating that NWMO is transforming itself from a study organization to an implementing one and will be expanding its staff and governing Board. He urged the audience to go to the new NWMO website.

An international view was presented by **Tom Isaacs** of the Lawrence Livermore National Laboratory in the USA (no relation to E. Isaacs, the W. B. Lewis lecturer). There are currently 31 countries storing spent fuel, he noted, and a very few doing processing. Most existing plants, especially in the USA, expected reprocessing and did not build large storage facilities. But security concerns, especially after the September 11, 2001 attack, raised security concerns and reduced reprocessing capability.

Currently, he said, geologic repositories are the preferred method. After 20 years of development, a formal licensing application has been made to the United States Nuclear Regulatory Commission for the Yucca Mountain facility. There remains a debate about direct deposit versus reprocessing and a growing awareness of the inter-relationship between waste, security and the spread of nuclear weapons, he said in closing.

The final speaker was **Jo Ann Facella**, Manager of Social Research and Dialogue, at NWMO, who focussed on public acceptability. There are many factors, she noted, such as safety, responsibility, accountability, and fairness. Sustained and real citizen engagement is necessary, she stated, and closed by commenting that if a repository is built there must be a willing community.

Tuesday morning was devoted to further technical sessions, ending early to allow for the CNS Annual General Meeting that ran over the lunch hour. *(See a report on the AGM in the CNS News section.)* The Canadian Nuclear Association took advantage of the conference to hold its AGM earlier the same morning.

The second plenary session took place Tuesday afternoon, focussed on *Human Resources and Infrastructure.*

Leading off was **John Froats**, President of CANDU Owners Group, who titled his talk, *COG – Delivering for CANDU Owners.* COG members, which include all of the utilities operating CANDU type units around the world, share knowledge and experience and support joint programs on issues of common interest. A major study is underway on "knowledge management". A large amount of knowledge and experience exists, Froats noted, the challenge is how to find and access it. To compile and index it is labour intensive and expensive. As businesses, utilities focus on the short term, he commented.

Bill Garland, Executive Director of the University Network of Excellence in Nuclear Engineering (UNENE), spoke on *Tacit Knowledge Emergence.* Professional development and tacit knowledge transfer are not being adequately addressed by university program, he stated. More study is needed on how we learn. The transfer of tacit knowledge needs a more hands-on approach than traditional lectures, and there must be motivation, he noted.

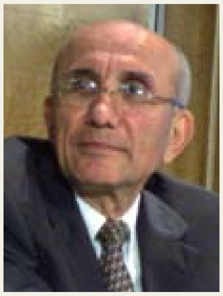
The role of industry in human resource development was outlined by **Martyn Wash**, President of the Organization of CANDU Industries (OCI). OCI now has 105 member companies, he reported, of which 98 are in Ontario. A survey of members indicated that most see an impending shortage of skilled manpower in the long term and many are introducing training programs.

Providing a different perspective was the team of **Bark Keenan**, Vice-President, Nuclear HR at Ontario Power Generation, and **Susan Brissette**, President of WiN Canada. Their presentation was based on a workshop held during the WiN Canada annual meeting in February on Myths and Perspectives related to women in the nuclear workforce. The results are now on the WiN Canada website.

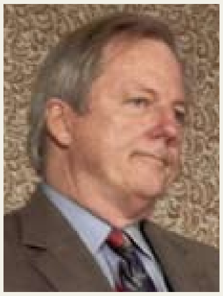
An active discussion ensued, touching on many aspects of the nuclear workforce, with particular emphasis on how to attract women and, to a lesser degree, how to retain those of retirement age.

That evening this year's **Canadian Nuclear Achievement Awards** were presented at a special dinner with musical accompaniment. The awards are a joint program of the Canadian Nuclear Society and the Canadian Nuclear Association and administered by a committee, chaired this year by Doug Hink. *(See the separate report on the Awards in this issue.)* Prior to the dinner there was a reception in the exhibit area.

The third and final plenary session was held on the Wednesday morning and featured presentations from each of the three companies vying for the proposed "new build" in Ontario: Atomic Energy of Canada Limited, AREVA, Westinghouse. However, since the provincial government had banned overt campaigning, each of the presentations was necessarily quite general in nature.



First up was **Ala Alizadeh**, Vice-President Marketing and Sales at AECL, who gave an update on the ACR 1000 design. AECL is just a designer, he noted, and its many partners are a key factor. There are multiple suppliers for all key components, he said. ACR 1000 is based on the CANDU concept of heavy water moderation and pressure tube but an evolutionary design to provide enhanced safety and greater economy. The innovations include slightly enriched fuel, light water coolant, and a robust containment capable of withstanding extreme events.



Next, **Bob Pearce**, Director of Business Development, Global AP 1000, for Westinghouse – Toshiba spoke about the "Global Deployment of AP 1000". AP 1000 is a further evolution of the many Westinghouse pressurized water reactor (PWR) designs around the world, he noted. It has been designed to meet all US and European licensing requirements, with an emphasis on standardization using proven components. With modular construction the aim is to have a 36-month construction schedule for a fleet of units. The design has been certified by the US Nuclear Regulatory Commission. They have contracts for four units in China, two in the USA and five further US utilities have applied for licensing.

Armand Laferrère, CEO AREVA Canada Ltd., focussed on his company's EPR design. Two of these 1600 MWe units are under construction, one in Finland and one in France and two ordered for China. He described the basic layout, noting that EPR has four safety "trains" giving it a predicted 10^{-6} per year core melt probability. There are passive as well as active safety features. The use of a "heavy reflector" contributes to a very high energy yield of 50,000 MWdays/tonne. Regarding the delays of the unit in Finland he acknowledged that they had been optimistic about the supply train and had encountered many questions from the regulatory authority.

Surprisingly, there were almost no questions posed to these three speakers.

At the lunch on the Wednesday, **Michael Binder**, recently appointed President of the Canadian Nuclear Safety Commission, spoke on the subject *Moving Forward: CSNC Future Directions.*

With the aid of often amusing slides he began by reviewing the general situation of growing electricity demand and environmental concerns, and made reference to the medical isotope incident of last December. On the last point he commented that many more people are now aware of "nuclear" and "isotopes". Almost as an aside he mentioned that CNSC is already discussing with AECL a life-extension of the NRU reactor.

The CNSC has grown to become a $100 million / year operation with a staff approaching 700, and, he said, is looking for more since almost a quarter are eligible for retirement within five years. He reported that the CNSC has become a partner with the newly created "Major Project Management Office" set up within Natural Resources Canada. A number of regulatory documents are in the works, which will emphasize a move towards international standards. Two new vice-president positions were created – for Regulatory Operations, and for Technical Support. He emphasized that the CNSC is independant of government but not isolated from it. "We will not compromise safety but we will not be a bottleneck", he asserted.

(Binder's PP presentation is available on the CNSC website.)

Student awards

Following the Wednesday afternoon technical and student sessions prizes were awarded for the best student papers, in three categories: doctorate; masters; bachelor. **George Bereznai**, Dean of Nuclear Engineering at UOIT and organizer of the student program presented the awards.

The winners were:

Doctorate — Markus Piro, Royal Military College
Paper: *Fuel Performance and Thermochemistry Modelling of CANDU Nuclear Fuel – Progress in Developing a Self Standing Integrated Code*

Masters — Drew Rankin, University of Western Ontario
Paper: *Hardware-in-the-loop(HIL) Nuclear Power Plant training Simulation Platform Design and Validation*

Bachelor — Pamela Yakabuskie, et al University of Western Ontario
Paper: *Radiolysis of Water Containing Dissolved Nitrogen Species*

George Bereznai, coordinator of the Student Conference, poses with Doctorate winner, Markus Piro and Masters' winner Drew Rankin. Bachelor winner Pamela Yakabuskie was unavailable.

The Conference was organized and run by a large volunteer committee chaired by Jim Harvie. Ben Rouben served as Assistant Chair. Other key roles were: Anne Greve, secretary; Ken Smith,.treasurer; Ian Hastings, plenary program; Wei Shen, technical program; Denise Rouben, registration; Dorin Nichita, audio-visual; Jeremy Whitlock, publicity; Frank Doyle, sponsorship.

The proceedings with the full technical papers and the plenary presentations wil be available by July.

The conference would not have been possible without the generous sponship of the following companies and organizations: AECL; Aecon; Anric; AREVA; Babcock& Wilcox Canada; Bruce Power; Cameco; CNA; Candesco; CANDU Services; E. S. Fox; Hitachi; Hatch-Sargent & Lundy; Hydro Québec; Kinectrics; Lou Champagne Systems; MGP Instruments; NB Power; Newman Hattersley Ltd.; Nuclear Logisitics; Nuclear Safety Solutions; Ontario Power Generation; PermaFix Environmental Services; Power Workers' Union; RCM Technologies; SNC Lavalin Nuclear; UOIT; Wardrop; Westinghouse.

The next CNS Annual Conference will be held in June 2009 in Calgary, Alberta.

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From the Opening Plenary Session of the 29th CNS Annual Conference

Nuclear Recycle

by William H. Hannum

Abstract

Sensible recycling of used nuclear fuel will allow nuclear power to satisfy the early dream of environmentally responsible, essentially unlimited energy at a reasonable cost. This will require a multiple-pass nuclear fuel cycle. Technologies for recycling used nuclear fuel are available that will resolve the most challenging nuclear waste issues and will significantly simplify the task of controlling the potential for weapons proliferation. A major effort is needed to build prototype facilities for processing used fuel from today's nuclear power plants, to recover material for use in fast reactors. As these technologies are being developed and implemented, many additional nuclear power plants based on today's single-pass nuclear fuel cycle will be needed to meet near term demands for energy.

Introduction

This is an exciting time to be involved in the nuclear power business. Existing nuclear power plants are operating very well. They are largely paid off, and are running flat-out, minting money. Generating companies can see the need for additional base-load capacity, and there are no real competitors to nuclear power to fill this need. But there are doubts and challenges on the horizon.

I am delighted to have the opportunity to address this gathering on what those challenges are, and on ways to address them.

Disclaimers

Let me begin with a few disclaimers and qualifiers:

- I do not speak on behalf of any program or company. The opinions expressed are my own;
- My opinions do not necessarily coincide with those of the U. S., or of any other government or government agency;
- I do not wish to promote a particular technology; only an approach. I have full mconfidence that there are smarter people than I who will find a way, given the goal and freedom to achieve, to develop the practical details;
- I am speaking of an advanced technology. The need for advanced technologies must not be used as an excuse to defer addressing immediate problems. Advanced reactors capable of efficiently recycling used nuclear fuel will be needed if nuclear power is to grow significantly in the long run; but such technologies will not be developed if nuclear power does not grow significantly in the short run. This is a *chicken and egg* issue.

The current situation

For this audience, I don't think I need to belabor the need for additional energy. One simple table should suffice:

Table 1

Population	U. S. + Canada	0.3 B
	India + China	2.5 B

Relative per capita energy use 10 : 1

If, in the next decade of so, India, China, and other areas such as Africa, increase their energy use to, say, 20% of that of the U. S. and Canada, world energy demand will effectively double, regardless of what happens in the U. S. and Canada.

On the supply side, it is clear that nuclear power will be needed to supply much of this demand.

Coal is facing stringent new and expensive emission restrictions, potentially even CO_2 taxes; natural gas is now prohibitively expensive (and wasteful) as a fuel for base load; there are few, if any, good, new sites left for major hydro installations.

Windmills, moonshine whiskey to fuel our cars, and coal plants with upside-down smoke stacks to sequester CO_2 may help, but they will not do the job. The stability of our civilization requires massive expansion in the use of nuclear power.

As for nuclear power, several new reactor designs are available that offer simplifications and economies, with greatly improved safety. Some of these designs already have licensing approval by regulators in the U. S. and elsewhere. Even some politicians are speaking favorably of nuclear power.

So, if the situation is so positive for nuclear power, why do we have to go halfway around the world to see construction cranes actually building new nuclear power plants?

Aside from the lack of a competent energy plan, and the fact that utilities do not seem to want to take action on their long-term plans, there are two serious, legitimate concerns that need to be addressed:

- Nuclear waste, and
- The threat of nuclear terrorism.

No single technology will solve all our energy problems, but properly managed, recycling will resolve the nuclear waste issue, thereby removing the first of these impediments to nuclear energy becoming a major, potentially dominant resource in meeting our energy needs.

The threat of nuclear terrorism will not be solved by burying our head in the sand, and burying partially-used nuclear fuel in a hole in the ground. Recycling, if properly implemented, is one action that will significantly reduce the threat of nuclear terrorism.

Today's Nuclear Power

I don't think I need explain for this audience that using a major part of the energy content of mined uranium requires the use of fast reactors, where all of the uranium and other transuranic elements contribute to the neutron balance. And recycling is required to keep the fission products from poisoning the neutron balance.

We know how to build fast reactors; several are currently running very successfully, producing significant quantities of electricity. But these reactors are not coupled to an appropriate recycle technology. The few fast reactors that are currently operating are orphans, whose only fuel comes from weapons programs and whose wastes are as bad as that from single-pass reactors.

Thus, today's nuclear power is mainly characterized by single-pass (once-through) nuclear power plants that use less than 1% of the energy content of the ore mined. The remaining 99% is considered to be an untreatable, hazardous waste that is strangling the prospects for nuclear power. CANDU reactors do somewhat better than plants using enriched uranium, and the French recover and recycle some plutonium, but these approaches are still woefully inefficient ways to use uranium.

This does not need to be the case.

When I was in high school, I studied psychology by reading that classical expert: Dear Abby, and her *Advice to the Lovelorn.* I recall two specific bits of wisdom from that:

On one occasion, a writer said: *I've been going with this girl for 3 years, and I can't get her to say "yes." What should I do ?*

Abby responded: *What's the question?*

Another time, a writer said: *I've tried flowers, candy, and even liquor, and I can't get her to say "Yes." What should I try next?* Abby's response: *Try another girl.*

Applying that wisdom to our situation, we see the following:

What IS the question?

It has been said: *It is easier to reach your goal if you know what your goal is.*

To use nuclear power to address the world's energy needs, we need to effectively use our uranium resources. To do that, we need to address two challenges:

- How do we transform the used fuel from today's single-pass reactors into fuel for fast reactors?, and;
- How do we recycle fast reactor fuel so as to effectively utilize the energy content of the original ore?

For 40 years, we've been trying to find a way to adapt the PUREX process to the task of separating material from used single-pass reactor fuel to fuel fast reactors. PUREX is the process that was developed to separate weapons usable material from used nuclear fuel. Envisioning this as the foundation for an enduring nuclear energy economy, the PUREX technology was made publicly available, and a demonstration commercial reprocessing facility (West Valley, New York) was built and operated. This strategy could have led us to *a fast-breeder* based economy if the world were a more peaceable place. But it is not.

This strategy fell apart when it was recognized that it would lead to international commerce in plutonium, as other countries built PUREX type facilities. With plutonium widely available around the world, it would be difficult to prevent the uncontrolled spread of nuclear weapons.

This has become almost a moot point today. There are now vast quantities of plutonium and enriched uranium spread around the world. The threat of nuclear proliferation, and even nuclear terrorism, has grown dramatically with the spread of centrifuge technology and equipment. Further spread of PUREX type facilities would be one more source of nuclear weapons material.

Are there alternate ways of recycling used fuel for use in fast reactors, in the light of concerns over nuclear waste and the threat of nuclear weapons proliferation and nuclear terrorism?

Try another process:

The desired process should take the used fuel, recover all of the usable energy content, and leave a waste stream that can be dealt with comfortably. Chemists are clever, and have come up with several processes that will accomplish this. I will speak briefly of two such processes: a used-fuel separations technology, and a fast reactor recycle technology.

After introducing these technologies, I will spend the remainder of my tune addressing the implications that large scale recycle will have on nuclear power and its waste, and on the threat of nuclear proliferation.

You will note that I distinguish between a *recycle* technology and *reprocessing,* which is the term traditionally applied to the PUREX process. You will also note that I speak of *used nuclear fuel.* Used nuclear fuel should never be referred to as waste.

I will then conclude with an outline of what will be needed to pursue such a strategy.

Used Fuel Separations

The first process I will discuss goes under the name UREX. This is an adaptation of the PUREX process. It focuses on extracting a "clean" waste stream that contains no plutonium or other transuranics and no uranium. This is the inverse of the traditional PUREX process. As with PUREX, the used fuel is dissolved in nitric acid. Fission products and then uranium are chemically extracted. Then the residue is reduced to metallic form, which, after blending back an appropriate amount of uranium, is used to make fast-reactor fuel.

The product is relatively clean, radiologically, so it is envisioned that certain fission products would be blended into the product to help protect it until it reaches a secure site and is used in a fast reactor.

Fast Reactor Recycling

The other technology I will speak of is called *pyro-processing.* In principle, this is a reasonably straightforward process. A batch of used fuel is chopped and placed in a bath of chloride salts. An electrical current is then passed from the used fuel to a collector. The salt (KC1-OC1) is such that plutonium and the other transuranic elements (Np, Cm, Am) are the most efficiently transferred. The process can be run so that essentially no plutonium or other transuranics remain in the salt. Uranium is partially transferred, partially left in the salt. A significant fraction of the fission products carry over or are encapsulated as the plutonium collects; the remainder is left in the salt.

After extracting the plutonium and other transuranics, the salt is cleaned by first collecting the remaining uranium. Then the fission products are chemically removed, and the salt is returned for the next cycle.

Thus, the products are:

- Fission products with no uranium or transuranics;
- Clean uranium; and
- A melange, containing all the plutonium and other transuranics, some uranium, and a fraction of the fission products.

This third mixture is not pretty, but it is an ideal fuel for recycling back into a fast reactor.

Waste

Both of these processes have the distinct advantage that the waste output is naturally segregated into several distinct streams. Let me remind you that the hazard of nuclear waste falls into three time categories. For the short time period (months to a few years), used fuel is both thermally hot and emits intense radiation. This is a storage period. This is the case whether the fuel is to be recycled or treated as a waste.

The second (medium) period is dominated by Cs and Sr. These materials emit significant radiation (they are used in commercial processes, such as food irradiation and well-logging). They are also soluble, so if they are considered waste, they must be contained until their radiation dies away - a few hundred years. Several waste forms, including borosilicate glass and a ceramic waste form known as *syn-rock,* have been shown to be more than adequate for this. Hopefully, at some point these materials can be diverted to productive use, such as food preservation.

The waste problem with the single-pass fuel cycle, where partially-used fuel is classed as waste * without any processing, is the presence of plutonium and other transuranics in the waste stream that remain radioactive for very long times. If either the separation or the recycle technology discussed above is employed, this third, very long-term part of the nuclear waste problem goes away, since all of these materials are sent to the fast reactor as fuel.

With complete recycle, the nuclear waste problem is reduced to a few hundred years, where proven containment strategies are readily available.

A mature recycle economy

Before getting into proliferation, I need to sketch what a mature recycle economy would look like.

Fast reactors will initially be fueled with enriched uranium and plutonium that has been declared excess from nuclear weapons programs. There are hundreds of tonnes of such material, much of which is stored in secure bunkers, but a considerable amount is still in unaccounted stores and in scrap. Existing stocks of used fuel, and additional quantities generated by current and planned single-pass nuclear power plants will be processed, with the product used to fuel additional fast reactors. The fleet of fast reactors, once started, will operate on a closed fuel cycle, where the site receives only depleted, natural, or recycled uranium, or material to be incinerated. The products shipped from the fast-reactor complex will be electricity, processed nuclear waste that will decay to harmless levels in a few hundred years, and very minor quantities of material requiring special handling. Later, the fast reactor cycle can be modified to provide initial fueling for additional fast reactors as needed.

Proliferation liabilities

In discussing the potential impact of recycling on proliferation risks, let me first address the question: *Can the separations and recycle technologies discussed above be used to produce nuclear weapons materials?*

For the UREX process, an additional step would be necessary—one that separates plutonium from the other transuranics. Either that, or the separations plant could be fed with specially irradiated (i.e., very briefly used) fuel, so that the plutonium in the feed would be uncontaminated with heavier isotopes. The system would then have to be operated in a totally off-normal fashion. It would seem that any modest form of surveillance would be able to detect such a diversion.

Since UREX is a continuous process, a diversion would take a considerable time. It is unlikely that there would be more than a few such plants, and it is expected that these plants will be located in advanced industrial countries, where alternative means of acquiring nuclear weapons materials would be easier than bypassing surveillance. The safeguards policies and procedures would be based on, but simpler than those of weapons-based PUREX plants.

The process could be subverted, but this would be difficult, time-consuming, and easily detected. Safeguards processes are well developed.

The pyro process has two additional safeguards features. Being a small-scale batch process, it is likely that the recycle plant would be co-located with the fast reactors it services, so any off-site shipment would automatically be suspect. Even if specially selected used fuel, high in plutonium and low in higher isotopes, were fed to the process, it would still not yield weapons usable materials, because the process does not cleanly separate plutonium from uranium. Further, all operations will necessarily be conducted in highly shielded facilities, and any materials removed from the facility would have readily identifiable radiation characteristics. The subsequent process to separate out plutonium would be a totally foreign process.

The process could be diverted to making feed material for a PUREX type process, but would not itself produce weapons-usable materials.

In either case, strict safeguards and accountancy procedures will be required, but there is no reason to suspect that safeguards would not be technically straightforward.

These modest additional safeguard concerns must be weighed against the dramatic reductions in the risk of uncontrolled spread of nuclear weapons that will result from an effective recycle program.

Proliferation benefits

The first substantial impact on the threat of nuclear terrorism or weapons proliferation will be to provide an efficient means of "denaturing" and incinerating excess nuclear weapons materials. Fast reactors can do this some five times faster than the current generation of reactors, with far less complication. And the used fuel, after denaturing, will not become another complicated *special* waste. In a fast reactor, even much of the scrap from the nuclear weapons programs can be used as fuel.

The system will provide a market for used nuclear fuel, rather than leaving it as a temptation. Perhaps as important as anything else, with a market, there will be a credible basis for much tighter inventory control on all nuclear materials than there is at present.

When the fast-reactor system is mature, there will be no inactive inventory of plutonium anywhere.

There will be no *plutonium mine,* which some people postulate could be a hazard in the distant future.

The system will minimize the need for enriching uranium, simplifying the problem of safeguarding these facilities. Any effort to construct a uranium enrichment facility or a PUREX type of facility would be *prima-facie* evidence of a nuclear weapons program.

A brief word is in order here on the general question of nuclear terrorism. While the public perception is that plutonium is the biggest concern, this is far from the truth. While plutonium makes the best bombs, a uranium weapon is much easier to construct and easier to hide. Reactor-grade plutonium would make a far less threatening weapon than would uranium. Since the advent of centrifuge enrichment and the A. Q. Kahn network for obtaining this technology, enriched uranium is far more available than plutonium.

How do we get to a mature recycle economy?

There are five things that are needed to pursue this path:

1. Construct a substantial number of new evolutionary-design nuclear power plants. This will accomplish the following:
   - Address immediate power needs
   - Rebuild the infrastructure
   - Put money into the system

So far, there are very promising plans, but little action in the United States or Canada.

2. Construct a large-scale separations plant to recover recyclable materials from current used reactor fuel.
   - Resolves the politically sensitive nuclear waste issue.
   - Provides a reliable supply of fuel for an expanding fleet of fast reactors

Toward this end, a program called the Global Nuclear Energy Partnership (GNEP) includes a commercial-scale demonstration plant to separate long-lived radioactive materials from current "nuclear wastes," and to prepare them for incineration.

GNEP provides a credible and sensible justification for building such a facility. Again, the plans look good, but action is needed.

3. Construct a prototype fast reactor, fueled with surplus weapons materials.
   - The technology is available, as are credible designs. The economics and reliability of such a plant need to be demonstrated.

The GNEP program has solicited proposals for the construction of a fast reactor to consume the long lived radioactive materials recovered from used fuel in the separations plant (Item #2).

The design of the reactor should recognize its much broader potential, beyond the political objective of incinerating troublesome materials from current used nuclear fuel.

4. Design and construct a demonstration facility for recycling fast-reactor fuel.
   - This technology has been demonstrated only at the feasibility stage. Detailed designs are necessary to establish the economics and operability of such a facility.

This facility will be necessary, even if the fast reactor is no more than an incinerator.

5. Revise international non-proliferation and safeguards agreements to reflect recycle technologies and to discourage new enrichment facilities.
   - While primarily a political issue, not a technical problem, this may be the most challenging part. But it will be even more critical if we do not proceed with recycling.
   - GNEP has proposed a scheme whereby selected, trustworthy countries or some international organization would provide enrichment services for those building single-pass nuclear power, with all used fuel returned to the enriching country. For smaller facilities, this service would be provided via sealed, plug-in reactor cores.
   - A program of full recycle, with appropriate transparency, would be a reasonable complement to such a program.

The GNEP program addresses the technical aspects, but this must be accompanied by a major diplomatic effort, that begin with an acknowledgment that the current Non-proliferation Treaty (NPT) has no enforcement provisions, and is quite ill-equipped to stem the spread of centrifuge enrichment.

Conclusion

The prospects for expanded use of nuclear power are the best they have been in over 40 years.

There are, however, serious impediments to expanded use of the current types of nuclear power plants: nuclear waste and the threat of proliferation.

An intelligent program of recycle is feasible. The basic technologies are available.

Recycle offers a secure path to addressing many of the short- and long-term challenges to effective use of nuclear power. Such a program will effectively address the nuclear waste issue, and will greatly reduce the threat of nuclear terrorism and weapons proliferation.

The biggest threat presented by recycle technologies is that they could be used as an excuse to defer or interfere with other necessary programs, such as constructing new evolutionary plants or GNEP.

With recycle, nuclear power offers an essentially unlimited energy resource with which to power a growing world economy.

From the Opening Plenary Session of the 29th CNS Annual Conference

Pressure Tube Reactors And A Sustainable Energy Future: The Ultra Development Path

by R. Duffey, Atomic Energy of Canada Limited, Chalk River, Ontario, Canada

Abstract

Nuclear energy must be made available, freely and readily, to help meet world energy needs, concerns over energy price and security of supply, and alleviating the uncertainties over potential climate change. The perspective offered here is a model for others to consider, adopting and adapting using whatever elements fit their own strategies and needs. The underlying philosophy is to retain flexibility in the reactor development, deployment and fuel cycle, while ensuring the principle that customer, energy market, safety, non-proliferation and sustainability needs are all addressed. Canada is the world's largest exporter of uranium, providing about one-third of the world supply for nuclear power reactors. Pressure tube reactors (PTRs), of which CANDU, is a prime example, have a major role to play in a sustainable energy future. The inherent fuel cycle flexibility of the PTR offers many technical, resource and sustainability, and economic advantages over other reactor technologies and is the subject of this paper. The design evolution and development intent is to be consistent with improved or enhanced safety, licensing and operating limits, global proliferation concerns, and waste stream reduction, thus enabling sustainable energy futures. The limits are simply those placed by safety, economics and resource availability.

1. Introduction: Classic, Lite and Ultra

With expectations of significant expansion in nuclear power programs worldwide and the resultant concerns about uranium availability and price, and the prior emphasis on simplistic fuel cycles, there is a growing desire to improve resource utilization by extracting more energy from each tonne of mined fissionable material. Attention is therefore being increasingly focused on fuel cycles that are more energy efficient, reduce waste streams and ensure sustainable energy futures. The developments usually focus on fast spectrum reactors for the distant future. There are also many compelling reasons to continue to utilize and optimize advanced fuel cycles in PTR (CANDU-type) thermal spectrum reactors, including "closable" and sustainable cycles. Hence the PTR development path utilizes complementary designs that are directed at specific customers and markets, both now for meeting present energy needs and for addressing future environmental and sustainability requirements. These are the PTRs that address the multiple requirements of energy security, competitive cost, sustainable fuel cycles, reduced waste storage and streams, and assured licensability, and I use CANDU as an example:

The CANDU "Classic", being presently the D2O/D2O (C-6) system, optimized for natural and slightly enriched uranium use to provide independence from uranium enrichment sources and hence supply surety, as a reliable and proven introductory unit, and which as a result has a slightly positive CVR and an extremely simple fuel design.

The CANDU "Lite", being presently the D2O/H2O Advanced CANDU Reactor (ACR) system, optimized for competitive power markets with lower capital cost and LUEC, using LEU to provide a slightly negative CVR and higher efficiency, and hence has a slightly more complex fuel with a burnable poison as in current LWRs but also able to use alternate fuel cycles as resources shift in supply and cost.

The CANDU "Ultra", being a D2O/H2O variant (SCWR), optimizing the development pathway for mass global deployment, requiring higher efficiency (50%), no core melt, size flexibility, cogeneration options and includes an alternate new fuel cycle (thorium), reduced licensing uncertainty, and implementing in a smooth development pathway that avoids switching the nuclear technology but capitalizes on the advances made in the thermal power industry.

Experience of building each builds towards building the next. The lessons learned, are the keys to success: effective project management, an assured and proven "buildability", and a defined and fixed cost with firm schedule adherence. This is not standardization of design as pronounced by some to reduce costs and uncertainty: it is learning from experience as an essential element of the "learning curve". After all, as a simple example, no one now buys an auto that is a sixty year old design, that has the same motor, efficiency, safety systems and features as that originally as was sold and developed all those years ago. The Super Critical Water Reactor (SCWR) is the true "concept car' of the future.

Assuring these elements of flexibility and continuity not only minimizes risk and maximizes returns; it also provides the owner/operator with an assured product for the full lifetime, and for whatever extension and flexibility that is possible in the foreseeable and unforeseeable future.

2. DC to AC: Waste to Energy

The learning concept is firmly embedded in this CANDU development pathway, as so-called Generations of reactors continuously evolve towards more efficient, safer, cheaper and simpler advanced reactors (Generation II to Generation V).

But there is another constraint to examine: that of fuel resources. A simple calculation [1] shows that although there is no shortage, there is a finite lifetime, because the present demonstrated fuel cycle (DC) without recycling is both wasteful and has too much unused energy in the spent fuel, which is often regarded as waste.

Many present thermal reactors (LWRs) use uranium as the main fuel supply, with some recycling of Pu mixed-oxide fuel (MOX). The cycle is essentially a once-through system, with fuel irradiated to about 40,000 MWd/t or so, and then stored until cooled and ready for Pu separation, or kept in interim storage buildings (e.g., Zwilag in Switzerland), until ready for sending to the underground repositories planned in many countries (Finland, France, Canada, etc.). As an order of magnitude, an operating once-through cycle 1 GW (e) LWR today uses about 180t/a of U for fuel [2].

With over 400 reactors operating today, present world demand is ~70,000 t/a. Today's estimates of identified reserves are about 5 MtU at a cost of <$130/kg, [3, 4]. Even allowing a doubling or tripling of this estimate to, say, 10 MtU, just 1000 reactors operating for 60 years will use all the world's cheapest uranium (or by about 60,000 reactor operating-years) with present fuel cycles technology.

Only the present 400 reactors could be kept going for another 150 years, leaving a shortfall is about 3000 reactors (or some of the need) in the anticipated energy future before 2050 or so. This is not a cause for alarm - there is plenty of uranium, and more uranium reserves will be found but at higher prices (cf. oil, gas and other commodity markets). Aggressively adopting recycling and increased fuel utilization might even allow up to 1500 reactors.

So there emerge at least two views of fuel cycles, which we may summarize as follows.

2.1 The traditional Demonstrated Cycle (DC) view

For those with near-term access to uranium, such as the US, France, and Canada, the uranium fuel cycle is already a demonstrated cycle (DC), and is fine while uranium is cheap and assuredly available.

There is always more uranium to find, even though the cycle is known to be unsustainable (as per the above calculations), and most current reactors (LWRs) are not particularly efficient fuel users.

When (or if) uranium becomes too scarce and/or expensive, all one has to do is switch to (breeder) fast reactors, and/or Pu recycle, even if it is more expensive and requires introducing a different reactor technology. Given the large initial Pu load for a fast reactor core, the transition has to occur well before U becomes scarce to maintain any growth in energy production. A number of countries already are planning or talking up this longer-term switch to a plutonium-driven recycle (e.g. Japan, France, Russia, China, Korea,), especially if they do not have long-term uranium supplies.

The U-switch point is far enough away, and it is too costly to use any alternate now in existing thermal reactors. Since spent fuel waste is not an issue and can be stored retrievably anyway and used in fast reactors. Some improved efficiency can even be realized by recycling the uranium in the spent fuel from LWR thermal reactors, such as the re-use of recovered uranium (known as RU) in HWR types that only need low enrichment.

2.2 The new Alternate Cycle (AC) view

For those without access to large uranium reserves, or needing energy supply surety, a new alternate cycle (AC) is needed that will ensure sustainable supply and smaller waste streams.

There should be a more intrinsically proliferation-resistant cycle, with no significant Pu generation, thus not requiring all of today's policing and international stress. It also must not require introducing a new reactor technology, and acknowledge the ownership and deployment of U-enrichment technology as a proliferation concern while still allowing vastly expanded reactor builds.

Such a fuel cycle is available now, using Thorium, which is more globally plentiful (perhaps 3 times more than U ?), so meets the future need. With careful fuel design and recycling, a thermal reactor gives a near breeding cycle, so is more sustainable with much lower (up to ten times less) waste amounts and storage needs. This Th-switch would enable more reactor deployment using today's reactor technologies and help stabilize fuel cost and supply, and avoids having to introduce many fast reactors.

Such an AC path is already being explored (e.g., by India, Norway, Canada and others), with the transition to a near self-sustaining predominantly thorium-fuelled cycle being initiated by burning Pu as the start-up fuel. The cycle thus reduces Pu inventories/stocks during transition to a primarily Thorium near-breeder cycle using separated U233.

This DC-AC schism and/or transition is real and could totally alter the global fuel cycle and the reactor deployment opportunities. In fact, some of India has already chosen to develop this AC route as a national priority. Such AC concepts are in fact not new; what is new is the concept that an alternate sustainable and closable fuel cycle may enable greater benefits from nuclear energy deployment worldwide.

3. The CANDU Ultra pathway

Because of inherent technical characteristics, of D2O moderation and distributed channels with flexible fuelling, PTRs have a great deal of fuel cycle flexibility and this has been the subject of significant R&D by AECL, and others. The combination of relatively high neutron efficiency (provided by heavy water moderation and careful selection of core materials), on-line fuelling capability and simple fuel bundle design mean that PTR reactors can use not only natural and enriched uranium, but also a wide variety of other fuels. These include:

a) re-cycled uranium into C6 and ACR;
b) thorium-based fuels with U233 recycle;
c) minor actinides "intermediate burner";
d) MOX fuels in ACR; and
e) re-cycled LWR and ACR fuel into C6/current CANDU fleet.

Synergistically, and to provide highly efficient reactors, advanced reactor concepts include the use of the super-critical/reheat PTR concept (GenIV) "Ultra" reactor[1], which can couple thermal efficiencies of some 50% using a proliferation resistant thorium cycle with a near-breeder cycle. In addition, the advanced PTR lends itself to indirect and direct hydrogen production, which can be coupled with a power grid, which then allows a greater usage of wind power.

1 Ultra-supercritical Thermal Reactor©

4. Observations and Conclusions

The optimization and development potential of the PTR design is coupled to the entire global sustainability model for future energy systems, via the fuel cycle and the reactor design, enabling sustainable resource use and the hydrogen age. This view is different from conventional or existing fuel cycle thinking, which envisages a shift in technology, and reliance on existing fuel cycles and raises the consideration and planning for when a DC to AC switch occurs, as it must.

In the meantime, current CANDU technology (C6 and ACR) can and will provide a logical enabling development path towards more efficient designs and fuel cycles.

Global nuclear fuel cycle must support and maintain international trade, and address energy and environment needs. While optimizing nuclear power, attention must be given to the associated fuel cycle and waste management technology to ensure economic and environmental sustainability.

Developing alternate "closable" fuel cycles (that require enrichment, reprocessing, separation and advanced cycles) meets all the projected global needs. CANDU technology and its PTR development path (Classic-Lite-Ultra) can help ensure that nuclear power technology remains competitive and contributes to national and international energy supply and security, while addressing proliferation risks.

David Torgerson (R) and his wife Dale are seen during a special retirement party held in Deep River, June 21, 2008. David retired in early May from the position of President AECL Research and Technology after 32 years with the company. The party was organized by Paul Fehrenbach, a former AECL Vice President and head of the Chalk River Laboratories and featured reminiscences from several other retired AECL executives.

5. Acknowledgements

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This paper summarizes the views established and presented in a series of strategy talks and papers presented by the author at the Carnegie International Centre in Moscow, Russia, 2007, prepared for the TU2007 Workshop in Beijing, China, and given at the ASME-JSME-CNS Conference ICONE 16, 2008, Orlando, Florida, Paper 16-48497.

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From the Opening Plenary Session of the 29th CNS Annual Conference

Nuclear Regulation and Gen III Reactors

by J G Waddington, B.Sc. P. Eng

Abstract

The paper discusses the challenges that reactors with a 60 year lifetime, licensed in many countries and operated by many utilities, present to the regulator. Issues of international standards, technology neutral regulation, design responsibility, configuration control, balancing sources of risk and their review, regulatory efficiency and cooperation, and integration of regulatory observations over time and space will be discussed.

Introduction

The increase in nuclear energy that is expected to occur over the next decades will put great strains on the design, manufacturing and construction capabilities of the nuclear industry world-wide. It will also challenge the regulators of the world to come up with better ways of ensuring even higher levels of safety at far less cost and time, if the opportunity of nuclear power to provide clean, cost effective energy to many countries around the world is to be realised.

The Renaissance

We are all aware of the expectations of the nuclear renaissance. The International Energy Agency predicts that the number of nuclear reactors in the world today may double over the next 20 to 30 years, with much of the expansion in Asia. That's 300 to 400 new reactors. Lest anyone have doubts, I note that the USNRC has already received applications for 23 new units, with another 11 expected over the next 2 years. The ageing of power stations in the western world; the widespread understanding that we have to get really serious now about the effects of industrialisation and energy use on the world's environment; the need to drastically curtail carbon dioxide and GHG emissions; the dramatic expansion of Asian economies, particularly China and India; and the desire to reduce reliance on volatile parts of the world for sources of energy have come together to produce a "perfect storm" of an expansion; an enormous pressure for the development of environmentally friendly sources of power in the immediate future. The International Energy Agency notes that it is not capital that we lack in facing these challenges- it's time.

I would like to present to you a number of issues that this expected expansion will bring to the industry and to the regulatory agencies in particular.

Standardisation

It is reasonable to assume the generation III reactor designs that are available now will provide bulk of these numbers. Let us assume that there are, say, 10 designs available on the world market. Let's further assume that the 300 to 400 reactors are made up of 20 copies of the least popular design, and, say, 50 copies of the most popular design, each spread around a ten or more countries.

Clearly, the nuclear business has entered the age of mass production. To achieve this situation at reasonable cost, designs must be standardised-, not just the core but the whole plant, given that we know that the achievement of a very low probability of a severe accident is as dependent on the whole plant, not just on the components of the nuclear island, and as a result the whole plant is as much a part of the licensing process as the reactor itself. There are not enough people available in the regulatory agency of any country to do much detailed review other than on standardised designs, and I doubt any utility in the world wants to spend the cash on a one-off.

None of this is new; the USNRC understood this issue 20 years ago, and put in place a design certification and licensing process to deal with it well ahead of the demand. The UK and French Governments both asked the IAEA to look at adequacy of their nuclear regulatory systems when faced with this expansion, and the IAEA recommended that in both countries, the informal prelicensing review that has been the most common way for regulators to start looking at new designs be changed to a formal process leading to design certification. The French Government has already changed their legislation to allow for that. It's well past the time when we followed the same route here in Canada, and changed our regulations to give legal authority to the CNSC to issue a formal design certification. We will discuss this issue more in a moment.

The Perception of Safety

A few years ago, the aircraft business faced a similar expansion issue. They expected a doubling of the number of passengers traveling by air over a period of several years and hence a nearly doubling of the number of planes flying. All things being equal, it was reasonable to expect that the number of planes that fall out of the sky each year would also double. Twice the number of reports of crashing aircraft in the newspapers did not seem to be good PR, and the airline industry wanted the number of actual accidents to stay the same;- i.e. they were looking to halve the accident rate. They recognised that much effort was needed to achieve this, and in the intervening time they have put much effort into SMS- or Safety Management Systems -safety culture to us.

Expansion will bring more safety issues to the nuclear industry too, and we will have to follow the lead of the aircraft industry. To quote Dr Nils Diaz 's speech at a conference in Moscow two years ago, many countries with no past experience with nuclear power have expressed interest in building nuclear power plants. These countries include Belarus, Egypt, Indonesia, Malaysia, Turkey, Poland, Vietnam, Nigeria, and various countries in the Middle

East. Even if a foreign vendor is responsible for the design, construction, and commissioning of a plant, the recipient country has the obligation to ensure the existence of a strong infrastructure that can guarantee continuing attention to safety for a period as long as a century or more. There are many components of the necessary infrastructure, including legal and regulatory capability, educated and trained manpower, a stable electrical grid, access to financial and industrial resources, and the nurturing of an appropriate safety culture in the generating entity.

In other words, the regulators and operating organisations in new countries will need to develop high levels of knowledge of operations and and of how to achieve a high level of safety, including safety culture. I contend that they do not need a detailed knowledge of reactor design to do this. We will discuss this too in a moment.

The Design Authority

In the early 1990's a letter was received by the IAEA's Director General from V P Bryukhanov, the Station Director of Chernobyl. As I remember, his letter started out "I have just been let out of prison after 4 years". His letter took issue with the IAEA, who, in their initial assessment of the Chernobyl disaster, put the onus for the accident squarely on the operator. His objection was that, as station director, he was not responsible for the design faults in that reactor, notably the combination of a large positive void coefficient, a positive temperature coefficient and the positive reactivity that occurred in the reactor when the shut off rods were first inserted. With hindsight, there is no doubt that the operators at Chernobyl made significant operating errors that made a big contribution to the disaster, but Brukhanov had a point. Should he have been held responsible for design flaws in the RBMK reactor? How could he be?

In a certified design, when the reactor designer has obtained a design certificate from the regulator that a potential utility can use to substantially shorten the site and operating license processes, what responsibility does the operator have for the design? If a design weakness is discovered, whose responsibility is it to ensure all 20 to 50 other plants of the same design are corrected? In say 10 different countries? If a design change is required as a result of an incident, who decides if that design change must be duplicated on all other copies of the design? When a design is changed, is it still certified? Or if a design isn't changed when it was supposed to be, is it still certified? Who decides, and on what basis? Who makes the application? Clearly, there are many more issues to design certification in the Generation III world of multiple copies that just making the licensing process more efficient, important though that is. In a mass produced product , I submit that must be the designer. Would you accept Air Canada was responsible for the design of the plane you are flying? No you would not. It's Boeing. Or Airbus.

Maintenance of Design Knowledge

In the early days of the nuclear business in Canada, the design was shared between the reactor designer, AECL, and the utility and architect engineer, Ontario Hydro. The conventional wisdom is that the design of Pickering was 80% AECL, 20% OH; Darlington was 20% AECL and 80% OH; and Bruce was somewhere in between. Ontario Hydro had a large design staff to deal with this.

The design staff has largely disappeared at Ontario Hydro. The small utilities never really had them, though even they were operating with a staff ratio of about 1 "Full Time Equivalent" for every MW generated. For Generation III reactors, this ratio needs to drop to 0.75 FTE's /MW, or even perhaps to 0.5 FTE's /MW to really make a dent in operating costs - and to make it possible to find the qualified people needed to run and maintain all these plants and maintain their configuration control. To expect every plant to have enough technical staff to be able to capable of maintaining the "Design Authority" responsibility seems a very unwise expectation. Of course every operator must know as part of its operating knowledge the basics of design; the basis for its safety; the equipment and operating configurations that must be respected to ensure a very low probability of serious accidents; and the minimum specification required of all its components. But in the future, they will not be experts in design. INSAG-19 discusses the issue of maintaining the design integrity of nuclear installations throughout their operating life and notes:

Nuclear power plants are complex machines. They are composed of many interdependent systems which must operate in a manner that meets the design intent over a period of many decades. This long period of operation means that a plant will undergo change throughout its life. The changes can arise as a result of

- the physical ageing of the plant's systems, structures and components;
- the obsolescence that inevitably occurs in many of its hardware and software elements;
- feedback from operating experience
- research on unexpected design issues arising during its life;
- changing engineering or regulatory standards;
- changes in performance expected from the plant; and
- changes in the organization or practices of the operating company.

To maintain the very high level of safety expected of a plant requires that design changes arising from these or other sources must be made with a full understanding of all the design information for the plant and the specifications for each system and component; of the engineering compromises and assumptions made by the designers about operation and lifetime; of why the plant was designed the way it is; and of the interactions with other systems and components which could affect safety.

INSAG-19 also notes:

- The accessibility of design knowledge is not a trivial matter. The amount of data is huge, as it includes, for example, original design calculations, research results, mathematical models, commissioning test results and inspection history. Further, many design change issues can be complex.
- Failure to ensure full knowledge of how plant design is maintained and to manage design changes adequately will, over the lifetime of the plant, result in decisions being taken on modifications, back-fits, changes in operating procedures and specifications for spare parts without a full understanding of the effect that these decisions may have on the safety of the plant. Unintentional consequences that could affect the safety of the plant are likely to occur in these circumstances, and the possibility that an accident could happen as a result will likely increase.

So what is the role of the operator here? The UK Health and Safety Executive have a lovely expression for it. The Operator must be an "intelligent customer". Now most operators in this room would say- quite rightly- "We are- and we don't need a regulator to tell us that!" But the UK HSE does clarify what it means. An intelligent customer requires technical expertise that gives it:

- sufficient expertise to understand and support the safety basis on which the Licensee operates;
- knowledge of the limitations and boundaries of the safety cases and of how these may change over time, or as circumstances change;
- the capability to oversee and, where necessary, develop and determine relevant safety and engineering standards, and to ensure the standards are met.

It seems to me that the nuclear renaissance is unlikely to expand very quickly if the level of technical support needed to maintain the responsibilities of full design authority for a Generation III design is expected to be retained by the staff of the nuclear power station or its utility.

Regulatory Expectations

Regulatory agencies around the world uniformly state "the licensee is wholly responsible for safety". Liability legislation in every country says so. Hence the regulator holds the operator fully responsible for the design as well as operation. When I joined the AECB/CNSC in 1975, the designer was considered to be a contractor to the utility, with no responsibility for safety at all. As an aside, one consequence of this thinking in Canada, is that questions of design and analysis that remained after the current fleet was licensed- known to you all as GAI's- have taken for ever to resolve. The Regulator required the utilities to solve them, and the designer was not held responsible by the regulator.

In the early days of the nuclear power program, politicians wanted to get the industry up and running, and didn't want the man in the street to have to say "who do I sue if my home is contaminated from a nuclear accident". Hence the Nuclear Liability Act in every country makes the operator wholly responsible for the results of any accident. Regulators have taken this to mean that operators are responsible not just for operational safety, but also for all aspects of the design. The legislation in every country was written to licence just the operator, and hence the regulator only had the holder of the operating licence to deal with. And after all, the licensee is the organisation that's making the risk–he's operating the reactor, right?

From an engineering and real safety point of view, the idea that, once the plant has been handed over to an operator, the designer has no formal responsibility for the design is, in my view, nonsense. As we have seen, the operator is responsible for operating to specific equipment and system specifications, operating limits and configuration control; the designer ensures robustness of design and defines the minimum performance required of systems important to safety. Operators of Generation III reactors will not have all the knowledge and expertise to be able to meet the expectations of the regulator that they maintain responsibility for the design throughout life. They must instead be "intelligent customers".

So- just as we are on the brink of a dramatic expansion of nuclear power that the world REALLY, REALLY NEEDS, world-wide our regulatory model is based on an assumption which in the past was unsatisfactory, and in the future will be pure fiction.

This is no basis to maintain high levels of safety all around the world.

The USNRC- as usual- has shown the way to solve the problem. It's Design Certification, and regulatory cooperation.

Design Certification

The USNRC introduced the concept of Design Certification 20 years ago to recognise two imperatives to reduce licensing costs; the early review of new designs, and the need for standardisation. In June 1988, the NRC issued NUREG-1226, "Development and Utilization of the NRC Policy Statement on the Regulation of Advanced Nuclear Power Plants." The NUREG provides guidance on the implementation of the policy and describes the approach used by NRC in its review of advanced reactor design concepts. We now have to go further than NUREG 1226. The size and urgency of the renaissance requires regulators and the industry to sort out the questions about Design Certification that we raised earlier in this paper. Here are some more. If a design is certified in one country and the regulator in another country wants to change it, is it still certified? Who sends the letter out to the operators of all the plants to say- you HAVE to put in a design change?

These are not new problems. Again, the aircraft business solved all most of them years ago, and we can learn from them. But nuclear regulators have to recognise the issues and put the necessary processes in place, including the international treaties and changes to national legislation that will eventually be needed.

There are many hurdles. The main one is the recognition by the regulatory agencies of the proper balance of responsibilities for safety between designers and operators. This need NOT change at all the public responsibilities of the operator defined by the Nuclear Liability Acts. What it will change is the situation that could occur after an accident happens and after any compensation has been paid by the operator's insurance company to the public.

Rationalisation of Requirements

At risk of annoying Boeing and its carbon fibre Dreamliner designers, it seems to me that there is far greater a variation in the basic design of reactor than there is in aircraft. To illustrate this, compare the difference in basic structure between the PWR and the BWR, the PHWR, and FBR, and then look at the differences between a Boeing and an Airbus. The task of coming up with internationally accepted rules will therefore be more difficult for the nuclear business than the aircraft business. But it has to be done. A regulator cannot use a set of design requirements that it has developed for one reactor type to regulate another reactor type of reactor. Instead there has to be some international agreement on requirements that are design specific. This should be easier to obtain.

The IAEA has developed "technology neutral" requirements that can be applied to every reactor design in its NS-R-1 document, "Safety of Nuclear Power Plants- Design", but these are at a very high level. No regulator would use these alone to regulate a specific design. Specific, detailed requirements that are not technology neutral have been developed by every regulator, and are the result of many knowledgeable people's efforts. To illustrate the point, a group of 12 European utilities developed common requirements for just one design- the LWR (European Design Requirements for LWRs). There are 4000 requirements identified in this document. Since it was the utilities that developed the document, it covered much more than just safety, but it illustrates the point that you CANNOT LICENSE BY TECHNOLOGY NEUTRAL REGULATORY REQUIREMENTS alone.

Regulatory collaboration to obtain some common recognition of the safety of each design is obviously essential. Nils Diaz and Richard Merserve, both Chairs of the USNRC, have been pushing hard for such collaboration, resulting in the formation of the Multinational Design Evaluation Program (MDEP) at the IAEA. Note that it was originally MDAP- Approval, not Evaluation, but reality- in terms the desire by all regulators to be masters in their own countries, crept in and the goal was scaled back.

INSAG has published a new report, INSAG-21, which makes the case for such collaboration. It notes that:

> "The basic goal of a multinational reactor safety review should be to ensure that a design determined to be safe in one country does not have to be substantially modified to meet licensing requirements elsewhere. This can be achieved if the requirements that must be satisfied in one country are consistent with, or at least not significantly different from, those that must be satisfied in another. The importance of this basic goal reflects the general expectations of the public and the industry that fundamental safety principles must be universally satisfied."

The difficulty is that the devil is in the details. There are many different ways of satisfying the fundamental safety principles, and it is not reasonable at the moment to insist on a specific set of national or international standards. Nevertheless, multinational review will help to harmonise global safety approaches.

There is international agreement in the endpoint of the regulatory regime for every design- the risk of a severe core accident has been essentially agreed for new plant at 10^{-5} for core damage, and 10^{-6} for severe accidents, and every Generation III design does much better than that.

To me, this illustrates the way forward to harmonise standards if regulators are really serious about it. Probabilistic Risk Assessment is a powerful tool for looking at the relative risks presented by different failure modes or event sequences, and the efficacy of potential solutions. If the same analytical tools are used with the same rigour to analyse different requirements and their solutions, the real contribution to safety of both requirement and solution can be compared and understood. This gives a dispassionate route to identifying internationally, for a given reactor type, what different design requirements called up by different jurisdictions really contribution to the safety of a design, and what may be a mutually acceptable solution. An example of the problem to be solved is given by the problems faced by the EPR in Finland. The EPR was designed to criteria agreed between France and Germany, and completed an extensive review process by the French regulatory authority. It is currently being reviewed by the USNRC for design certification. The Finnish regulatory agency requires that a steam generator tube leak should not result in the release of any primary coolant to the environment, and AREVA had to make changes to deal with this new requirement, resulting in delays and increased costs. This difference has occurred despite reported collaboration between the regulatory agencies of France, Finland and the US. The Finns also noted additional work would be needed on details of the reactor core design, the reactor emergency borating system, the containment liner, emergency cooling systems and severe accident response. It is essential to the greater goal ensuring affordable, environmentally sound energy be available world-wide that ways of resolving these differences of opinion be found. The advantage to national regulators of such regulatory collaboration and hard-nosed technical comparisons, rather than comparisons of regulatory theory, is that their own national rules for each type of design WILL GET BETTER in terms of assuring safety, if they are scrutinised on a factual and results basis. The challenge for the world's regulators is all the greater in that the designs of all the Generation III reactors are nearing completion. There is not much time to get this right.

As an aside, for those who still have difficulty accepting the probability figures from these analyses, please note that the precise numerical values of probabilities arising in PRA analysis is not so important; what is important is that analyses that are to be compared are of the same quality, and represent as logically as possible the real systems of the plant.

Exchange of Operating Experience

This topic is probably the area that has one of the greatest benefits to safety in the long term. Standardisation, recognition of the wider implications of design certification and of the realities of design authority all provide a basis for a marked improvement by learning from world-wide operating experience gained from each fleet. Standardisation should make it much easier to agree on uniform codes to identify like components and their failure modes, uniform definitions of failure categories, and to apply lessons learned. Regulators and designers must be as heavily engaged as operators in the development of uniform and comprehensive reporting processes, as all have a vital stake in the results. Regulators particularly will have a far greater possibility in integrating and understanding observations about the real safety of a particular plant and the performance of the operators within its jurisdiction when there is ready access in a common form to a much greater experience base than is available domestically.

It will require a great deal of goodwill, common purpose and effort by the regulators to achieve these gains- but they are worth it.

Conclusions

I have tried to illustrate some of the challenges that the deployment of 300 to 400 Generation III reactors over the next 20 to 30 years will pose, particularly for regulatory bodies world-wide. They are substantial, but they have to be addressed if the expansion is to take place and, at the same time, maintain a high level of safety and even improve it. Underlying all is a recognition by regulators that, in their own interests as well as that of the world community, they have to think globally as well as nationally, and be prepared to collaborate with their colleagues on a scale that has not been seen before. Failure to do so is likely to put a large, and probably unnecessary additional burden on the development of an essential source of energy for the future.

Here in Canada, it is essential that the CNSC start the process to incorporate a formal design certification process, and develop the necessary changes to the regulations that will give it the appropriate legal regime. I believe the legislative change is not difficult; what will be difficult is changing the underlying regulatory mindset that has been in place for 50 years.

Each year the Canadian Nuclear Society and the Canadian Nuclear Association join forces to honour individuals and groups who have contributed significantly to the Canadian nuclear program.

As for the past several years, the awards are presented at a special dinner held during the Annual Conference of the Canadian Nuclear Society.

This year seven awards were presented during the dinner held Tuesday, June 3, 2008, in three categories: one **R. E. Jervis Award**; two **CNS Fellowships**, and three **Outstanding Contribution Awards.**

R. E. Jervis Award

The R. E. Jervis Award was established in 1992 by former students of Professor Robert E. Jervis of the University of Toronto and the CNS. It is for excellence in research and development carried out by a full-time graduate student in nuclear engineering, radiochemistry, or the use of research reactors in applied chemistry or chemical engineering. The Award consists of a $1,000 bursary.

The winner is **Emily C. Corcoran** of the Royal Military College.

Citation

Emily C. Corcoran is awarded the R.E. Jervis Award for her research in support of the fuel design for the Advanced CANDU Reactor (ACR).

Her doctoral research work has demonstrated a skilful linkage of fundamental physiochemical theory and diverse experimentation undertaken in collaboration with Atomic Energy of Canada Limited - Chalk River Laboratories (AECL-CRL) in the pursuit of the fuel design for the ACR. In particular, she has contributed to the development of a thermochemical treatment of phase equilibrium for irradiated fuel and has undertaken supporting experimental work using coulometric titration equipment at AECL-CRL to study the oxidation of SIMFUEL. She also has used high-temperature X-ray diffraction equipment at the Royal Military College (RMC) to study the potential phase decomposition of the burnable neutron absorber proposed as the central element in the ACR fuel bundle.

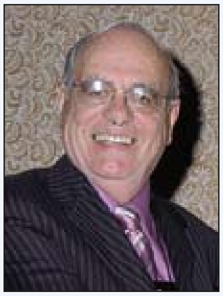
Her research work is published in the International Journal of Materials Research and has also received much attention at the 2007 International Light Water Reactor Fuel Performance Conference in San Francisco. She was recognized with the best paper award in the Ph.D. category at the Canadian Nuclear Association/Canadian Nuclear Society Student Conference in 2007.

Ms. Corcoran is about to complete her PhD programme at RMC under the supervision of Drs. William T. Thompson and Brent J. Lewis. Recently, she has accepted a position of Assistant Professor of Nuclear Engineering in the Department of Chemistry and Chemical Engineering at RMC.

CNS Fellowship

CNS members who are appointed Fellows of the Canadian Nuclear Society belong to a membership category established by the Society in 1993 to denote extensive contributions to the Society and meritorious service to the nuclear filed in Canada. In the tradition of learned societies, CNS Fellows are entitled to add the letters "F.C.N.S." to abbreviations denoting degrees and professional certification following their name.

Two CNS members were named Fellows of the Canadian Nuclear Society.



Ken Smith

Citation

Ken Smith has served the Canadian nuclear industry for close to fifty years: at Chalk River on R&D of fuel channels, at AECL Sheridan Park on Gentilly-1 fuel channels, then as AECL's Senior Project Engineer for Picketing-A, and subsequently Bruce-A, interfacing with Ontario Hydro. Ken developed effective change-control techniques to control the installation of design changes on Picketing A and Bruce A. He also spent several years as Director, Uranium Exports, with Energy Mines and Resources (now NRCan).

Following retirement, Ken was a Consultant. He gained an enviable international reputation publishing *UNECANNEWS, a subscriber-funded* monthly newsletter, which presented accurate information on developments in the Canadian nuclear and uranium industries.

Ken still found time to serve very actively, for at least the past 15 years, on CNS Council, variously as Treasurer, Vice President, CNS President (2000-2001), and Financial Administrator since 2004. Ken has been on the Organizing Committee of all Annual Conferences since 2000. Throughout, Ken established very high standards of financial reporting in all CNS activities. Ken has made a multitude of important and lasting contributions to the CNS.

Jeremy Whitlock

Citation

Jeremy Whitlock has made significant contributions to the Canadian Nuclear Society and the Canadian nuclear program. His role as a communicator has been remarkable. The website he created over a decade ago and still maintains (Canadian Nuclear FAQ) is as popular as those of the major organizations. His whimsical "Endpoint" essay has been a highpoint of the *CNS Bulletin* for several years.

Jeremy has been an active member of the CNS for over two decades from his days at McMaster University where he obtained a Ph.D. in 1995. (His doctoral thesis was on a still very topical subject "Reduction of the Positive Void Effect in a CANDU Lattice Cell").

After being elected to the CNS Council he soon chaired the Education and Communication Committee. He was elected 2nd vice-president, progressed to 1st vice-president, and, in 2003, became the youngest president of the Society. He continues to be an active member of the CNS Council.

As a reactor physicist with Atomic Energy of Canada Limited he has conducted many difficult analyses. Last year he became Manager of Safeguards and is applying his scientific and communication skills in that challenging international field.

Outstanding Contribution Award

The Outstanding Contribution Award recognizes Canadian –based individuals, organizations or parts of organizations that have made significant contributions in the nuclear filed, either technical or non-technical. It was established in 1989 by the Canadian Nuclear Association. The award is in the form of an engraved brass plaque mounted on a wood panel.

There were three winners in 2008.

Neil Craik

Citation

Neil Craik has served the Canadian nuclear industry for almost fifty years, and continues that service as a strong supporter and advocate for nuclear power, especially in his home province of New Brunswick.

Mr. Craik has had several notable areas of nuclear service, ranging from his initial Canadian nuclear experience with the KANUPP reactor in Pakistan; the Gentilly-1 experimental reactor, the following CANDU-6 reactors in Gentilly, Point Lepreau, Korea, Argentina, Romania; studies on other reactors such as the CANDU-3 and CANDU-9; and the ACR. Even since "retirement", Mr. Craik has provided a proactive and vocal support to the New Brunswick nuclear power program, and defended nuclear power on many fronts.

His skill in leading both individuals and organizations toward worthy goals with high integrity is the hallmark of Mr. Neil Craik's career.

Juris Grava

Citation

Juris Grava, recently retired from Bruce Power as the Design Authority, earned universal respect throughout the Canadian and overseas nuclear community through leadership, ethics, integrity, vision and professional standards.

Juris joined Ontario Hydro upon graduating from Queens University (Hons. Engineering Physics, 1974) and worked principally at Bruce except for commissioning Wolsung 1 and continued international exposure through WANO and conferences. Juris performed prominent roles Bruce 3/4 and 1/2 refurbishments.

Juris influenced others throughout his career as Shift Supervisor, Training Superintendent, Manager of Steam Generators, Business Development, Maintenance and Plant Design Engineering.

Juris promoted, encouraged and sponsored participation in CNS, conferences and industry forums. He contributed extensively to COG and CSA committees, including vice chair of N290s.

Juris led and mentored by example, finding pragmatic solutions to sometimes contentious issues while maintaining high standards of nuclear safety, and mutual respect for the views of others. He advocated and implemented changes in management systems (methods, execution, and metrics) for the benefit of Bruce and the industry.

He has earned this special recognition from his peers and the CNS membership.

Ian Wilson

Citation

One of the most difficult roles in any advanced technology industry is that of explaining its importance to the public and to governments. For nearly two decades, Ian Wilson has been a principal public defender of nuclear power. His first experience in this role was with the Porter Commission in the late 1970s and early 1980s, as Ontario Hydro's Manager of Public Hearings.

After joining the Canadian Nuclear Association in 1985 as Vice President Technology, Ian played a leading role in the industry's participation in such events as the Ontario Nuclear Safety Review, the Ontario Demand/Supply Plan hearings, and the Seaborn Environmental Review Panel on the concept of geologic storage of nuclear fuel waste.

Ian's influence in shaping the CNA was far greater than public review panels. In the late 1980s, the CNA launched its first public information program designed to win back public trust in nuclear technology. Ian played a principal role in determining the strategy and information content of that campaign. Subsequent successful campaigns by the CNA have been based in large measure upon the methods and successes of that first effort.

For his long efforts in defending the public aspect of Canada's nuclear industry, Ian is recognized for his achievements with the nuclear industry's Outstanding Contribution Award.

29th Annual Conference of the Canadian Radiation Protection Association

by Michael Grey

*[**Ed. Note:** The author is a Health Physicist and Occupational Hygienist with Candesco Corporation in Toronto. He is a Past President of the Canadian Radiation Protection Association.]*

"Building Bridges" was the theme of the 29th Annual Conference of the Canadian Radiation Protection Association, which was held in Saskatoon, Saskatchewan from June 2nd through June 5th, 2008. The Conference attracted 118 delegates, 18 exhibitors, and 54 papers.

On Sunday, June 1st, Areva and Cameco hosted 27 conference delegates on a tour of the McArthur River Mine and McClean Lake Mill sites. The group flew to Points North, SK where high winds made for a memorable landing. At Points North the group split into two; one group travelled by bus to the McClean Lake site while the other group (including the author) flew to McArthur River. At McArthur River there was an introductory presentation on the site and its operation after which the group descended to the 640 metre level of the mine for a tour of the operations on the level below the ore body. After lunch, the group flew back to Points North and travelled by bus to McClean Lake for a tour of the JEB Mill, the Tailings Management Facility and the Sue Open Pit Mines.

The Conference itself included presentations by

- Dr. Jack Valentin, Scientific Secretary of the International Commission on Radiological Protection (ICRP), on "The 2007 Recommendations of the International Commission on Radiological Protection";
- Chris Clement, Director of the Radiation Protection Division of the CNSC, on "From Recommendations of ICRP to IAEA Basic Safety Standards to CNSC RP Regulations: Bridging the Gaps";
- Dr. Norm Gentner, Chair of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), on "UNSCEAR's Mandate: Sources and Effects of Ionizing Radiation";
- Sylvain Saint-Pierre, Director of Environment and Radiological Protection for the World Nuclear Association, on "Towards a Greater Harmonization of the System of Radiological Protection, Views from the Global Nuclear Industry";
- Dr. Doug Chambers, Director, Radioactivity & Risk Studies, SENES and consultant to UNSCEAR, on "Current Estimates of Risk from Radon at Work and Home";
- Dr. Bill Angel, University of Minnesota & Chair, World Health Organization, International Radon Project, Prevention & Mitigation Working Group, on "Radon Monitoring and Mitigation"; and
- Dr. Jack Cornett, Director, Radiation Protection Program, Health Canada, on "Polonium-210 Contamination in Canadians from across the Atlantic".

Dr. Patrick Moore of Greenspirit Strategies Ltd gave a public lecture on Monday evening entitled "Searching for a Sustainable Energy Future" which provoked a lively debate. This session was held at Convocation Hall, University of Saskatchewan and it was sponsored by the Canadian Nuclear Association.

Tuesday afternoon was devoted to a series of presentations on the Canadian Light Source (CLS) at the University of Saskatchewan, which is a 2.9 GeV synchrotron used to produce intense beams of photons with energies from the infrared through hard x-rays. The speakers included Richard Florizone, Jeff Cutler, Dean Chapman, Mohamed Benmerrouche and Grant Cubbon, all from the CLS. This session was followed by tours of the Canadian Light Source and the Saskatchewan Research Council's Radioanalytical Laboratories and Slowpoke reactor.

Dr. Richard Osbourne, the first President of the CRPA, was made a Honourary Life Member of the Association at an Awards Luncheon held on Wednesday. Dr. Osbourne is also the CRPA's nominee for the Sievert Award; the recipient of that award will be announced at the IRPA 12 Conference that will be held in Buenos Ares in September 2008. Ray Ilson of Dalhousie University was presented with the Founder's Award, Kevin Bundy of the Canadian Nuclear Safety Commission was presented with the Distinguished Achievement Award and Michèle Légaré-Vézina of The Ottawa Hospital was presented with the Meritorious Service Award. The winner of the CRPA Student Paper Contest was Maxim Mitchell of McMaster University.

A post-Conference training course on "Communicating Risk to the Public" was given by Alvin Calder and John Burke of Burke Calder Media Strategies. The discussions included the proper sequencing of key pieces of information and the methods that will help ensure that your audience's concerns are addressed. Role playing and videotaping of mock public meeting were used in the training.

Steve Webster chaired the Local Organizing Committee for the 2008 Conference, assisted by Debbie Frattinger, Sunil Choubal, Wayne Tiefenbach, Brain Bjorndal, Skeeter and Carla Seier, Miles and Marilyn Riegert, William Steward, Mohamed Benmerrouche and John Takala. Financial support for the Conference was provided by Cameco, Areva, Canadian Nuclear Safety Commission, Health Canada, Canadian Nuclear Association, Canberra, Saskatchewan Research Council, MarShield, Monserco, Saskatchewan Ministry of Advanced Education, Employment and Labour and the University of Saskatchewan.

The CRPA's 2009 Conference will be held in Montreal, Quebec from May 23 - 29. The theme for the conference will be Human Performance and Risk Management, which will place the human being in the heart of radiation safety.

Canada's Oil Sands: Nuclear Power in an Integrated Energy Economy[1]

by Eddy Isaacs, Ph.D., Executive Director, Alberta Energy Research Institute

Summary

At a time of the expansive global growth in energy demand and the peaking of conventional oil, the Canadian Oil Sands have emerged as the largest new reserves to supply oil to world markets. Bitumen production in 2006 averaged 1.25 million barrels per day (an increase of 18% over 2005 and an 88% increase since 2000). If this trend continues Canada will be positioned as one of the world's premier suppliers of oil for many decades to come.

The Oil Sands are one of the world's most challenging and complex oil resources. They require considerable amount of energy, water and land area to produce, resulting in contaminated tailings ponds, air emissions of concern and copious greenhouse gas (GHG) emissions. As the need to protect the environment and reduce GHG emissions moves higher on the public agenda Canada's ability to grow the energy supplies from oil sands will be severely test.

This paper focuses on the current and emerging methods and innovations that can be applied to produce these unconventional resources to value-added products with a decreasing impact on the environment. The paper will also describe the benefits and challenges for nuclear energy in the oil sands as a solution to the need for substitutes for natural gas in oil sands production and upgrading and in meeting Canada's GHG emission targets.

The Oil Sands And The Global Energy Picture

The International Energy Agency (IEA) projects that global primary energy demand will increase by 1.6% pa from 2000 to 2030, reaching an annual level of 112 billion barrels of oil equivalent. The increase will be equal to over 50% of current demand. The world will remain heavily reliant on traditional forms of energy with fossil fuels expected to supply over 80% of global incremental energy demand through 2030 [1]. The IEA has also, for the first time, sounded a serious warning regarding the increasing market tightness for oil beyond 2010 and predicts that OPEC's spare capacity will decline to minimal levels by 2012 [2].

By all accounts, conventional sources are declining with the majority of oil producing countries having reached peak of oil production and, globally, reserves are not being replaced with new discoveries. However, the world has over twice as much supply of heavy oil and bitumen than it does conventional oil. Not including hydrocarbons in oil shale, it is estimated that there are 8-9 trillion barrels of heavy oil and bitumen in-place worldwide, of which potentially some 10% are commercially exploitable with current and emerging technology [3]. Canada alone has an estimated initial volume of crude bitumen of 1.6 trillion barrels with 11% or 175 billion barrels recoverable under current economic conditions [4]. Current daily oil (bitumen and synthetic crude) production has risen to 1.25 million barrels. This figure is expected to reach more than 3 million barrels by 2020 based on a moderate growth case [5].

There are a number of key factors enabling the current oil sands expansion: the increase price of oil due to high demand and declining reserves of conventional oil; the favorable fiscal investment climate in Canada; the potential of this vast resource with minimal finding costs; the proximity to the largest oil market in the world; and technological innovations that have significantly reduced the supply costs of bitumen and bitumen upgraded to synthetic crude oil. Production of the oil sands is dependent, however, on finding effective solutions and the technologies to address the risks associated with sensitivity to international oil prices, increasing production costs due to labor shortages, cost and availability of energy for both the production of the resource and upgrading to higher valued products, market limitations, and land water, air, and increasingly, greenhouse gas issues.

Producing "Technology Oil"[2]

Oil sands are composed of a mixture of sand, clay and other mineral matter (80-85 wt. %), water (2 -10 wt. %) and bitumen (3 -18 wt. %). The oil sands are spread across over 140,000 square kilometers of Northern Alberta, Canada and are contained in sand and carbonate formations divided into four sections: Athabasca oil sands, Cold Lake oil sands, Peace River oil sands and Grosmont Carbonate. The bitumen in the oil sands has a density that exceeds 1,000 kg/m^3 (°API less than 10) and is virtually immobile at reservoir temperatures (viscosities of the order of 1x10^6 centipoise).

Table 1 summarizes the major current and future development projects in the oil sands in three deposits; at the present time there are no projects in the Grosmont Carbonate deposit. A description of each of the major deposits and the current and developing technologies used to extract and upgrade the bitumen to higher valued products is described in the sections that follow.

Surface Mining – Athabasca Deposit

The Athabasca is the single largest oil sands deposit, occurring from the surface to a depth of 750 m. It is the only deposit where open-pit mining operation is possible currently to a depth of about 75 m of over-

1 This paper is an expanded version of the Author's Extended Abstract for 17th Convocation of the International Council of Academies of Engineering and Technological Sciences (CAETS), Tokyo, Japan, October 2007.

2 We have coined the term "technology oil" to describe the products derived from oil sands because technology development has been the key to allow bitumen to be produced at competitive costs.

Table 1: Oil Sands Projects in Three Deposits[6].

Operator	Project	Initial, bbls/day	Potential, bbls/day
Athabasca – Mining Projects			
Syncrude	Base Plant	300,000	600,000
Suncor	Base Plant	280,000	550,000
Albian/Shell	Muskeg/Jackpine	150,000	500,000
CNRL	Horizon (2008)	110,000	232,000
Imperial	Kearl (2010)	100,000	300,000
Petro-Canada	Fort Hills (2011)	50,000	190,000
Athabasca – In Situ Thermal			
Japan Canada	Hangingstone	10,000	30,000
Suncor	Firebag	30,000	-
ConocoPhillips	Surmont	16,000	110,000
Devon	Jackfish	35,000	70,000
Encana	Christina/Foster	30,000	400,000
Husky	Sunrise (2008)	50,000	200,000
Opti/Nexen	Long Lake (2007)	70,000	140,000
Petro-Canada	Mackay River (2009)	24,000	60,000
Synenco	Northern Lights (2010)	50,000	100,000
Total	Joslyn Creek (2007)	10,000	200,000
Cold Lake – In Situ Thermal			
Imperial	Cold Lake	150,000	180,000
CNRL	Wolf Lake/Primrose	50,000	120,000
Blackrock	Orion - Hilda Lake	500	20,000
Husky	Tucker	18,000	35,000
Peace River – In Situ Thermal			
Shell	Peace River	12,000	100,000

burden. An important feature of the oil sands deposits is that the sand grains are generally surrounded by thin water film (estimated at about 10 nm) which makes separation of the bitumen from the sand facile and reduces the energy intensity of extraction, compared to oil-wetted deposits such as the Utah Tar Sands. These projects tend to be large compared to in situ projects to achieve economies of scale.

More efficient use of shovel and truck (as large as 400 tonne) has replaced draglines and conveyer system as the main method of mining the ore. The use of slurry pipeline achieves separation of the oil from the sand matrix during flow and is designed to transport the ore from a remote mine site to the plant. More advanced mining technologies are being developed including mine face extraction. In addition research into processes that substantially reduce water use, are underway. Fresh water use in extraction processes is a major environmental concern for surface mining operations. Typically 2 to 3 units of fresh water are used to extract 1 unit of bitumen.

Oil sands mining operations are integrated with upgrading of the bitumen to synthetic crude oil which is about equivalent in value to conventional oil entering a refinery. The preferred upgrading technology is coking following by hydrogen addition. Hydrogen is produced using steam-methane reforming (SMR). Since the cost of upgrading is the single largest investment in the oil sands value chain, there is significant incentive to develop the next generation technologies to reduce the capital costs, reduce CO_2 emissions and reduce natural gas use [7].

In Situ Thermal – Athabasca Deposit

Steam assisted gravity drainage (SAGD) has emerged as the only in situ technology proven to be technically feasible and economically attractive for the thick Athabasca oil sands bitumen below about 200 meters. It is the technology currently used by all in situ operators and the acceptance of the commercialization of SAGD led to the upward revision of the established reserves estimates. SAGD is a major "breakthrough" in technology and is the culmination of aggressive public and private investments in research and development and field trials, and have led to the current major growth period for the oil sands industry.

In SAGD operations, typically, two 1000 m horizontal wells are drilled within about 5 meters of each other. Steam at about 250°C is injected from the top well which rises to form a steam chamber with bitumen and condensate draining into the production well by gravity. At steam temperature the viscosity of bitumen reaches that of water and flows readily; depending on the reservoir pressure artificial lift methods may be used to "lift" the bitumen to the surface.

In current operations, natural gas is used to produce the steam and in situ thermal operation typically uses 176 m^3 of natural gas/m^3 of produced bitumen (1000 scf/bbl). There is an increasing cost for natural gas which is also the fuel of choice for upgrading, heat, and power. This comes at a time when natural gas supplies have reached their peak and are declining. In addition, increasing in situ production is the major cause in raising CO_2 emissions from oil sands operations. There are a number of process development technologies that are being developed for reducing CO_2 emissions, natural gas use and water use. These include the use of solvents to enhance SAGD and reduce steam requirements, VAPEX, the solvent analogue to SAGD, combustion processes, the burning of bitumen instead of natural gas and electrical heating. A major "game changer" that is currently being applied by Opti/Nexen and is being considered by other operators, is gasification technology that use petroleum coke or bitumen residue as feedstock. Gasification can provide not only a source of heat for in situ production or extraction, power for operating the plant H_2 for upgrading but also a potential to access cheaper sources of CO_2 for carbon capture and storage. The Opti/Nexen project is unique in situ production and integrated upgrading that is self-sufficient in energy combining solvent deasphalting, thermal cracking, hydrocracking, gasification and cogeneration to produce a high quality synthetic crude oil.

In Situ Thermal – Cold Lake Deposit

Imperial oil is the dominant player in Cold Lake and is currently the largest in situ thermal producer in Canada. Cyclic steam stimulation (CSS) has been the preferred method of production involving the injection steam from single wells at sufficiently high pressure to cause parting of the reservoir allowing the steam to penetrate in channels to heat the reservoir and mobilize the oil. Following a soak period, the well is put into production and the heated oil and condensate flow back into the well. The process is repeated over several cycles. This technology requires similar amounts of natural gas per unit of production, as SAGD. The main advantage of CSS over SAGD is the more rapid reservoir response (higher initial oil rate). The main disadvantage is the lower ultimate recovery of about 25% compared to more than double that for SAGD. CSS is considered to be the most suitable for Cold lake formations while SAGD is most suitable for Athabasca formations.

In Situ Thermal – Peace River Deposit

Shell is the major lease holder and its holding contains over 7 billion barrels. A variety of thermal recovery technologies and well configurations have been tested over a number of years to overcome the difficulties associated with a bottom water zone. Current operations use multilateral horizontal cyclic steam stimulation technique and this technology is the basis of the major announced expansion. The environmental issues are similar to those described above for the other in situ thermal deposits.

Potential for Nuclear Energy in the Oil Sands

Natural Gas Becoming Disadvantaged

The growth of production from both integrated mining and thermal in-situ operations in the oil sands and the associated upgrading, refining and chemical industries all rely heavily on natural gas resources. Natural gas production in the Western Canadian Sedimentary Basin (WCSB), however, has reached a plateau and has begun to decline. With increased oil sands production and declining rates of natural gas supplies, natural gas requirements could reach 20% of total Alberta conventional gas production by 2020. Over the past several years, the price of natural gas has increased substantially and today we are witnessing the highest historical prices. In addition, increasing natural gas use results in expansive CO_2 emissions despite efficiency gains.

Entry for Nuclear in Oil Sands

The combination of declining supply, high prices and high CO_2 emissions provide urgency in decreasing the dependence on natural gas and a potential entry point for nuclear.

There are three alternatives to reduce dependency on natural gas consumption:

1. Improve thermal efficiency of the existing exploitation technologies such as SAGD, and CSS and reduce waste heat;
2. Develop new wave of production technologies that minimize natural gas consumption such as combustion and electrical heating; and
3. Develop alternatives integrated with oil sands operation such as gasification and nuclear technology.

In order for nuclear energy to be viable greater certainty is needed on the capital, fuel and operating costs of nuclear power so that the economics of displacing natural gas with assumption on an increasing carbon penalty can be ascertained. Regulatory delays must also be overcome so that nuclear plants are built in alignment with the development and expansion of oil sands facilities. In addition, the matching of reactors to potential oil sands application will be important. Potential synergy of nuclear in oil sands includes providing steam for SAGD and CCS, integration with steam methane reforming that is used to produce hydrogen for upgrading, direct hydrogen production through electrolysis and integration of nuclear with gasification. Conceptually, the integration of nuclear with gasification has a number of advantages including eliminating the need for an oxygen plant for gasification, the direct and substantive reduction in CO_2 emissions and the use of excess electricity for desalination of the tailings ponds and steam generation.

Conclusions

Innovation has been the key to developing the immense and complex Canadian oil sands resources. Production is expected to more than triple by 2020 reaching about 3 million bbls/d. As production increases, more advanced upgrading will be required to meet refinery specifications and increase value by co-producing clean fuels and petrochemicals.

New recovery technologies and "game-changers" will reduce and/or replace the use of steam based processes and provide options for natural gas displacement and CO_2 mitigation over the next 20 years. Gasification of coke/asphaltenes can replace natural gas and can be a source of heat, hydrogen, power and future fuels.

Compared to gas-fired plants, nuclear plans produce negligible CO_2 emissions, improve air quality and have the potential to integrate with existing oil sands operations. In the long run, the synergistic blending of nuclear energy with the next wave of oil sands recovery technologies and gasification improves efficiency and reduces emissions and provides a rational positioning in the transition to competitive thermo-chemical water splitting nuclear processes.

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LETTER TO THE EDITOR

Re: Bill Schneider's article entitled "What would warrant selection of CANDU?" in the March 2008 Issue of CNS Bulletin

Dear Editor,

It became clear when reading Bill Schneider's article that he may not be aware of some of the recent initiatives underway at CNSC. For example, CNSC has established a Memorandum of Understanding with AECL to expeditiously complete the pre-project design review of the ACR-1000. As well, since December 2006, CNSC has undertaken a number of other initiatives to strengthen its capacity and capability to undertake the review and licensing of major new facilities such as power reactors and uranium mines.

These initiatives include:

- establishing a new Directorate of Regulatory Improvement and Major Projects Management to manage the review and licensing of major new facilities;
- hiring over 100 new staff;
- deciding to join the Major Projects Management Office (MPMO) program, which is committed to a reduction in the time taken for licensing;
- streamlining the way CNSC approaches environmental assessments and integrating site licensing into environmental assessments thereby reducing the overall timelines by over 2 years;
- issuing key regulatory documents relating to site evaluation and design of new nuclear power plants (RD-346 and RD-337 respectively) and safety analysis for nuclear power plants (RD-310);
- committing to further streamline the licensing process by accepting a licence application to construct at any time during the licensing process; and
- committing to review any reactor technology if requested by a vendor or a proponent.

In conclusion, CNSC is in a position to fully support the various proposed new build projects anywhere in Canada. It will continue to ensure the operational safety of the existing CANDU fleet, including refurbishment projects, and will support expected growth in uranium mines and other facilities. CNSC's goal is to issue an operating licence within 9 years of receipt by MPMO of a completed project description.

Terry Jamieson
Vice-President, Technical Support Branch
Canadian Nuclear Safety Commission
13 June 2008

"Badge-Draw" Winners at the 2008 April CNS Reactor Safety Course

At the end of the CNS CANDU Reactor Safety Course, on April 2, 2008, 11 prizes were awarded by random draw from among badges returned by Course attendees.

The winners:

- Kristine Drew and Randy Peplinskie, both of AECL, won a CNS multitool
- Khalid Osman, of Wardrop Engineering Inc., Aurora Dranga, of AECL, and Alice Leung, of AECL, each won a CNS silk tie
- Juliet Luiz, of AECL, won a book
- Robert Chandler, of Wardrop Engineering Inc., and Todd Giroux, of AECL, each won a CNS sweatshirt
- Cecilia Leiva, of AECL, won a CNS golf shirt
- Tapan Sengupta, of Wardrop Engineering Inc., and Melanie Sachar, of AECL, each won a complimentary CNS membership for 2008

Congratulations to all the winners!

Gagnants de prix au tirage des porte-insigne au cours d'avril 2008 de la SNC sur la sûreté des réacteurs

À la fin du cours sur la sûreté des réacteurs, le 2 avril 2008, 11 prix ont été tirés au sort parmi les porte-insigne retournés par les participants au cours.

Voici les gagnants des prix:

- Kristine Drew et Randy Peplinskie, tous les deux de l'EACL, ont chacun gagné un ensemble d'outils de la SNC
- Khalid Osman, de Wardrop Engineering Inc., Aurora Dranga, de l'EACL, et Alice Leung, de l'EACL, ont chacun gagné une cravate en soie de la SNC
- Juliet Luiz, de l'EACL, a gagné un livre
- Robert Chandler, de Wardrop Engineering Inc., et Todd Giroux, de l'EACL, ont chacun gagné un chandail sport de la SNC
- Cecilia Leiva, de l'EACL, a gagné une chemise de golf de la SNC
- Tapan Sengupta, de Wardrop Engineering Inc., et Melanie Sachar, de l'EACL, ont chacun gagné une adhésion gratuite à la SNC pour 2008.

Félicitations à tous les gagnants!

Plans to Adapt Point Lepreau Ageing Management to New Industry Guidelines

G. Greenlaw[1], T. Gendron[2], J. Slade[1] and B. Rankin[1]

[1] NB Power Nuclear, Lepreau, New Brunswick, Canada

[2] Atomic Energy of Canada Limited, Chalk River, Ontario, Canada

Ed. Note: *The following paper was presented at the 29th Annual Conference of the Canadian Nuclear Society held in Toronto, June 1-4, 2008.*

Abstract

In preparation for PLGS life extension, NBPN spent considerable effort to evaluate the impact of ageing and to develop ageing management processes to maintain the required safety functions for extended operation. These were based on INPO AP-913.

Recently, the CNSC has been developing Canadian ageing management guidelines in line with the IAEA approach. In response, NBPN plans to document how current PLGS processes meet the new CNSC guidelines and to identify any areas for improvement. Best practices from utilities that have retrofitted IAEA guidelines and PLGS experience in applying risk-based methods for ageing management will be used to implement improvements.

1. Introduction

CNSC staff have recently presented their approach to ensure that Canadian nuclear power plants (NPPs) have effective ageing management programs (AMPs) and their intention to publish a new regulatory document, RD-334 [1, 2]. The proposed regulatory document will represent the CNSC's adoption and where applicable, adaptation of guidance established by the IAEA in draft safety guide DS382 [3].

Although regulatory guidelines for ageing management will be new to Canada, ageing management is not new to CANDU® utilities. NBPN has a relatively comprehensive and mature program at the Point Lepreau Generating Station (PLGS). Attention to ageing management increased significantly in the mid 1990s following a period of poor performance. At this time, NBPN undertook a major improvement initiative and began developing the current Management System Process Model. Ageing management activities expanded again in the late 1990s when NBPN began planning for PLGS life extension. Prior to IAEA/CNSC guidance becoming available, utilities have based their ageing management programs primarily on INPO AP-913 [4] and according to best practices borrowed from EPRI and other utilities. Regular WANO and INPO audits are a means of continuous improvement of these programs. Reduced plant incapability, unplanned maintenance, and rework are examples of tangible benefits from the improvements to ageing management at PLGS.

This paper briefly describes NBPN's initial review of PLGS processes in anticipation of the CNSC Regulatory Document on ageing management and plans to address the implications. Since the PLGS AMP is well established, NBPN does not believe that a major restructuring of station organization and processes is warranted at this time. It is considered important to adopt improvements from the Regulatory Document without major impact to the current PLGS management processes and while retaining other industry good practices.

2. Evaluation of new CNSC guidance

Our understanding from CNSC staff presentations, conference papers [1, 2] and informal communications is that a main driver for developing the new Regulatory Document is to establish a common set of benchmarks against which utility AMPs can be evaluated. Two main priorities for improvement are the adoption of a life cycle approach to ageing management and implementation of systematic and integrated AMPs. A related CNSC Regulatory Document RD-360 [5], which outlines guidelines for NPP life extension, describes a third ageing management priority, the Integrated Safety Review (ISR). These three priorities are discussed below.

2.1 Life-cycle approach

The CNSC has emphasised the need for early and proactive consideration of ageing management for all stages of a plant's life cycle: design, fabrication, construction, and commissioning, operation, and decommissioning. During the design stage for example, the CNSC recommends features to be incorporated into the design that will facilitate ageing management throughout the entire plant life.

Ageing was considered in the original PLGS design with knowledge of materials degradation from R&D and industry operating experience (OPEX), particularly from the early CANDU designs (NPD, Douglas Point, Gentilly-1, Pickering A, Bruce A). For example, problems with Cr-Mo steel weld cracking at Gentilly-1 led to a last-minute design change at Gentilly-2 and PLGS. Feeder piping was replaced at these stations prior to final construction, with SA 106 Grade B carbon steel to prevent

1 Canadian Nuclear Safety Commission

2 International Atomic Energy Agency

3 CANDU (CANada Deuterium Uranium) is a registered trademark of Atomic Energy of Canada Ltd.

4 New Brunswick Power Nuclear

5 Institute of Nuclear Power Operations

6 Electric Power Research Institute

7 World Association of Nuclear Operators

8 Nuclear Power Demonstration, a prototype CANDU reactor located in Rolphton, ON

this type of cracking. Materials, design allowances, and operating margins were selected for thirty-year service using the best knowledge at that time. Other features were specifically included in the design to facilitate ageing management. Although these examples are now out-dated, the heat transport system (HTS) autoclave system for corrosion coupon testing and the feeder freeze jackets were included in the original design to allow monitoring and maintenance of ageing materials, respectively.

Other design features have been incorporated after plant commissioning, in response to industry OPEX or improved technology. A good example at PLGS is the change from phosphate chemistry for the secondary system to "all-volatile-treatment". A number of other design modifications have been made over the years because the importance of features to facilitate inspection and maintenance is much better recognized now than it was when PLGS was originally designed. Examples are the installation of inspection ports on Boiler 3, water lancing ports on all four boilers, and access platforms around the primary heads of all four boilers. PLGS has also been proactive to implement instrumentation for on-line monitoring of chemistry and corrosion. Examples in the HTS are monitors for coolant oxygen content, Feeder On-Line Thickness, and Hydrogen Effusion (measures flow accelerated corrosion rate).

During design planning for refurbishment, many other improvements have been made based on the most recent information from OPEX and R&D. For example, improvements to feeder steel material specifications, fabrication procedures (welding and heat treatment), installation procedures, and design dimensions (wall thickness) are expected to eliminate life-limiting thinning and cracking. The technical bases for these improvements are included in the project design and design review documents. However, documentation with a greater ageing management focus might be recommended in future. For example, the CNSC is considering guidance about addressing ageing management and its influence on operational limits and conditions in a separate section of the Safety Analysis Report [2].

PLGS is presently in an 18-month refurbishment outage for extended operation. In view of this stage in plant life, current ageing management effort is focussed on:

- Ensuring fabrication, installation, and commissioning is compliant with procedures
- Protecting systems, structures, and components (SSCs) from degradation during lay-up
- Collecting baseline condition information for new components (feeders) and original components that are normally impractical to inspect (calandria vessel internals), and
- Updating AMPs for post-refurbishment operation.

2.2 Integrated safety review

The ISR described in the CNSC Regulatory Document RD-360 [5] is a comprehensive assessment of plant safety and meets the requirements of a Periodic Safety Review (PSR) outlined in an IAEA Safety Standard [6]. Elements of the ISR evaluate the effects of ageing on NPP safety, the effectiveness of ageing management programs for future operation, and the need for improvements.

In 2000, NPBN requested CNSC review and concurrence with PLGS refurbishment plans, to reduce the regulatory risk in proceeding with the project. At that time, the CNSC had no specific regulatory requirements or policies in place covering refurbishment for plant life extension and suggested early completion of a safety review in accordance with the IAEA Safety Guide 50-SG-012 on PSR [7], a precursor to the current Safety Standard [6]. Since other Western nations had prepared PSRs, there were precedents for improved regulatory certainty by following this approach.

NPBN recognized that the IAEA PSR Guide [7], which is designed for stations licensed for their entire operating life (the international norm), contained many safety inputs that are assessed more regularly in Canada because of the shorter licensing period (generally < five years). Canadian utilities are obliged to keep the station safety analysis relatively current to support the licensing process. PLGS also undergoes periodic assessments by other outside agencies. WANO carries out comprehensive and formal assessment of station management, technical support, and operations and maintenance on a three-year cycle. PLGS undergoes an annual detailed assessment of risk by the station insurance agency. PLGS takes the results and recommendations from these distinctly focused but related assessments as vehicles for station improvement and safety risk reduction.

The IAEA PSR includes other review elements that were already being pursued by the PLGS refurbishment project assessment initiatives. PLGS had introduced an Environmental Qualification program to assure that safety related equipment would remain operational under accident conditions, a Quality Assurance program, and a comprehensive Condition Assessment Program (CAP), all required elements for assessment under a PSR. The CAP was a very comprehensive and detailed evaluation of the condition of PLGS SSCs, taking several years to complete and generating 162 reports. The CAP was an important one-time program that provides the underlying basis for an on-going AMP, as will be discussed in Section 3. Other reviews had direct application to the PSR. These included studies related to safety margin improvements, reviews of PLGS against safety-related design changes for newer reactors (Wolsong, Qinshan, enhanced CANDU 6 design) and against the generic CANDU 6 probabilistic safety assessment, and reviews of PLGS design against current codes and standards and the ability of PLGS systems important to safety to meet unavailability targets.

NBPN decided to integrate the review of the above efforts into the PSR process and called it an ISR. NBPN consulted with the IAEA on this modified approach and they concurred. In 2003, NBPN contracted an external service provider to perform an ISR of PLGS. NBPN believes that the completed ISR meets the intent of the recently issued CNSC Regulatory Document RD-360 [5] with respect to ageing management.

2.3 Systematic and integrated AMPs

A demonstrated systematic and integrated ageing program is a key element of the IAEA/CNSC guidance to ensure continued fitness for service of all plant SSCs important to safety. The IAEA/CNSC approaches use Deming's Plan-Do-Check-Act cycle as a model for guidance and to evaluate the extent by which an NPP has systematic processes in place to manage ageing.

The processes at PLGS were developed in the late 1990s using

INPO AP-913 "Equipment Reliability Process Description" [4] that was prepared to assist member utilities to efficiently maintain safe and reliable plant operation. The INPO approach was selected at PLGS largely to meet the expectations of WANO reviews, which use performance objectives and criteria that are based primarily on best practices from the nuclear industry in the United States. Like the IAEA model, the INPO AP-913 model is also a Deming-type cycle to ensure continuous improvement. Both these models, if applied properly would result in effective systematic and integrated management processes. However, it would be difficult to assess management processes developed by one model using criteria from the other model because of some basic structural differences (e.g. terminology) between them. Demonstrating that the PLGS processes satisfy the intent of CNSC/IAEA model for ageing management is considered to be one of the primary risks associated with the new CNSC Regulatory Document. This issue is discussed in more detail later in this paper.

3. Status of PLGS AMP

Roughly simultaneous with the ISR to support development of a refurbishment project, PLGS continued to implement its Management System Process Model to improve station management and achieve station performance objectives. This process model included a tiered framework of Executive, Core and Support Processes, illustrated in Figure 1.

Fundamentally, these processes represent interlinked activities that support and enable station staff to meet performance objectives. Several of the Core processes have direct application to ageing management. These processes are shown in Figure 2 as they would apply to the IAEA/CNSC Plan-Do-Check-Act model. The key ageing management processes of ME-1 "Establish Maintenance Programs" and ME-2 "Monitor and Manage System Health" are used to determine the overall scope of maintenance and capital projects at PLGS.

Implementation of these processes is supported by a tiered set of documents. The overarching document is the station's Nuclear Management Manual, which describes the Management System and sets out the policies, principles and processes through which the station meets its performance objectives. These processes are supported by a hierarchy of Process References, Process Instructions, and Working Level Documents. With respect to ageing management, the PLGS processes are focussed on meeting equipment reliability requirements, where SSC ageing is a key input. Sub-tier procedures for system health monitoring and equipment program plans require the evaluation of ageing and other degradation mechanisms to establish management options. These procedures also address degradation from out-of-specification operation unrelated to ageing (e.g. mechanical damage from debris ingress or corrosion from a chemical excursion). In addition, the system health monitoring (SHM) program utilizes a functional failure and criticality assessment to ensure the nuclear safety consequences are adequately considered.

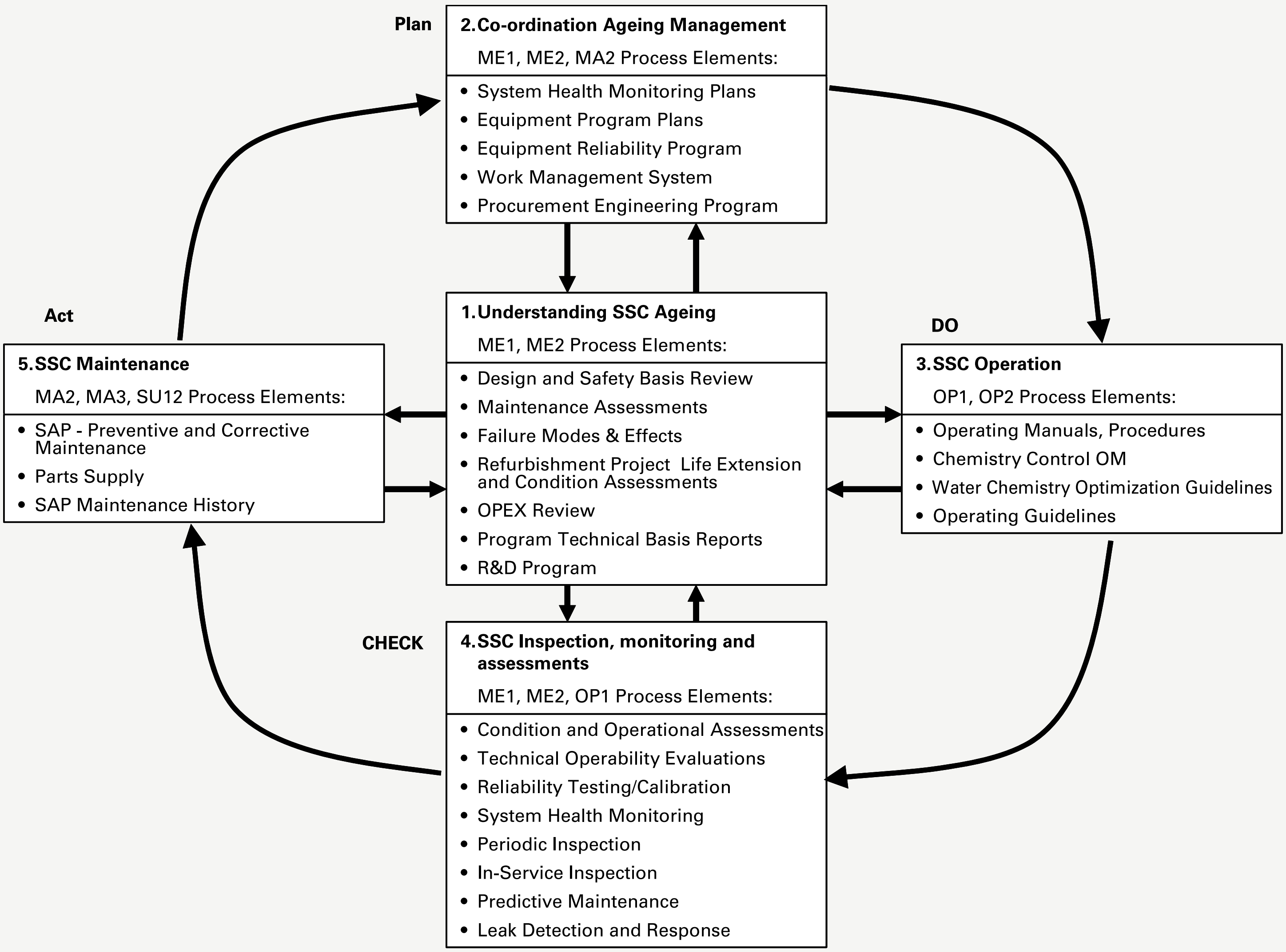
When the ISR was being performed, the higher tier process documents (e.g. ME-1 Establish Maintenance Programs, ME-2 Monitor and Manage System Health) were already completed. Some of the sub-tier documents that provide the technical basis for ageing management were also issued (e.g. plant life assessments, condition assessments, SHM plans) but many of the key documents were not started (e.g. equipment program plans, SHM reports).

Figure 1 High level map of the management processes at PLGS.

Executive Processes	Core Processes			
	Operate	**Maintain**	**Equipment Reliability**	**Design Configuration**
DM-1 Direct and Manage the Business	OP-1 Control and Monitor Station Equipment	MA-2 Provide Planning and Scheduling Services	ME-1 Establish Maintenance Programs	MS-1 Develop Modifications
DM-2 Manage External Relationships	OP-2 Control Chemistry	MA-3 Perform Maintenance	ME-2 Monitor and Manage System Health	MS-2 Implement Modifications
DM-4 Assess and Improve Performance	OP-3 Control Effluents			MS-3 Maintain Design and Safety Basis
DM-5 Manage Processes	OP-4 Fuel the Reactor			

Support Services		
SU-1 Provide Human Resources	SU-5 Provide Emergency Preparedness Services	SU-9 Provide Documents and Records
SU-2 Provide Environmental Services	SU-6 Provide Security Services	SU-10 Provide Financial Services
SU-3 Provide Training	SU-7 Provide Information Technology Services	SU-11 Provide Facilities
SU-4 Provide Personal Safety Services	SU-8 Obtain and Maintain Licences	SU-12 Provide Materials and Services

Figure 2 Mapping of ageing related management processes (see Figure 1 for process definitions) using the CNSC/IAEA model.



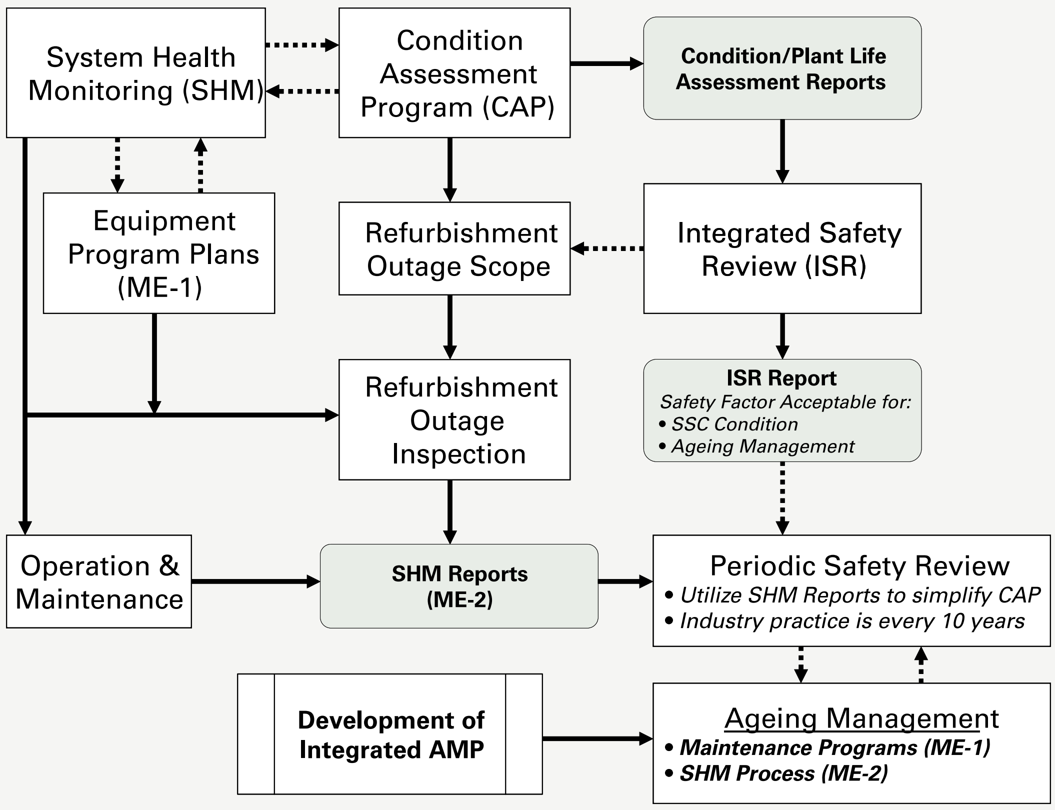
The Condition Assessment Program (CAP) that was performed to support the plant life extension assessment also formed the technical basis for the current PLGS SHM program. The CAP provided a one-time baseline plant condition assessment for the SHM program, which now updates SCC condition on an on-going basis. The interrelationships between programs carried out for the refurbishment project and the current PLGS ageing management processes are complex. Figure 3 shows a simplified flowchart of these relationships.

Since the CAP, PLGS has expanded and fortified the SHM process to provide appropriate assurance that CAP condition assessments remain valid and that safety margins for the refurbished reactor will not be compromised. The objectives of SHM are essentially the same as the CAP:

- Ensure equipment condition, health, and performance is effectively assessed, and identified when maintenance is required;
- Minimize equipment failures by proactively assessing and addressing degradation;
- Develop and control the mandatory surveillance program to proactively determine failures of safety related SSCs.
- To achieve these objectives, the SHM program includes the following fundamental elements:
- Staff responsibilities.
- Identification of applicable Systems based on defined criteria
- Development of a SHM Plan based on conducting Functional Failure and Criticality Analysis and assessment of degradation mechanisms.
- Development of a formal SHM Activity List, system walk-down requirements, performance indicators and targets, and record keeping and system logs to capture and trend pertinent data;
- Systematic review of OPEX, maintenance and operating history, design changes, and outstanding actions and recommendations;
- Preparation and issuance of formal periodic SHM Reports.

NBPN believes that the CAP and ongoing SHM program position PLGS to more effectively satisfy the requirements of future periodic reviews (PSR/ISR).

Figure 3 Simplified flowchart showing inputs to ageing management at PLGS.



3.1 Results of the ISR

The PLGS ISR was performed following the approach developed to integrate on-going PLGS safety, reliability, and licensing assessments and other specific assessments for the PLGS refurbishment project with the requirements of a PSR (Section 2.2). This section summarizes the ISR results related to ageing management. The ISR concluded that PLGS programs and processes adequately address the issues of degradation of equipment performance and safety margins for extended life.

The review found that PLGS surveillance and maintenance programs were consistent with international practice. Degradation monitoring of critical equipment was effective; the fitness for service of pressure tubes and feeders were cited as good examples. The assessment of equipment condition did not identify any issues requiring immediate corrective action. Because the Canadian industry has adopted the INPO/WANO experience for improving station performance, PLGS programs and processes for managing work incorporate current safety standards and practices.

Two aspects of the PLGS AMP were judged reasonably important to safety and needed improvement:

1. PLGS does not appear to have a methodical and documented system for selecting the SSCs to include in the AMP. (This has since been addressed – see Section 3.2)
2. The programs that contribute to managing the aging aspects of critical SSCs are distributed among several station organizations (Operation, Maintenance, Technical Unit – System & Engineering). Evidence is required to show that health monitoring, inspection, testing, maintenance, and age management programs are covering all aspects necessary for an effective AMP.

There were three additional observations:

- A person or small group is needed to co-ordinate the AMP activities and to ensure that all areas are appropriately addressed.
- The maintenance program should address program implementation planning, calibration facilities, reduction of overdue preventative maintenance work orders, updating of the preventive maintenance documentation to reflect changes in managerial structure and procedural process.
- The process of introducing new changes/improvements to the technical surveillance program could be improved.

The ISR identified four strengths in the PLGS AMP:

1. All of the elements of an effective AMP are in place at PLGS.
2. The objectives and scope of the aging related programs are compliant with the IAEA Safety Report Series No. 15 [8] (a guide pre-dating reference 3).
3. The CAP provided a solid baseline on SSC condition and the SHM group monitors the ongoing condition of the SSCs.
4. The Station Business Plan recognizes the need for ageing management and provides adequate resources.

3.2 Improvements since 2003

In the period since 2003, there has been significant progress in the development of the lower tier documents that are used for ageing management. The most pertinent ageing related documents are:

- Basis for identification of the systems important to safety, which addresses the first item for improvement (Section 3.1).
- SHM plans and reports for safety significant SCCs.
- Equipment program plans to manage SSCs that require complex arrangements to manage ageing and degradation effectively.
- Chemistry optimization guidelines to ensure materials degradation is minimized.

In 2003, NBPN also initiated an improvement program to address serious degradation of the major components of the HTS [9]. To apply industry best practices to the program, international industry guidance documents and regulations for ageing and life cycle management were reviewed. It was found that many industry guidance documents have a generic and broad scope for addressing plant-wide issues. Guidance for developing specific O&M activities to implement guideline goals and objectives are not normally included. Most documents focus on common components and ageing and are not optimal for the most serious PLGS HTS degradation, which is random and isolated. On the other hand, regulations are often very specific and not applicable to PLGS issues. In cases where the Regulator is prescriptive and/or risk averse, station programs focus on demonstrating compliance with rules and regulations.

Overall, it was found that the Nuclear Energy Institute Guideline for the Management of Materials Issues, NEI 03-08 [10] prepared following the Davis-Besse vessel head corrosion experience, was most easily adaptable for managing PLGS HTS materials degradation. It provides the most specific materials degradation management guidance and also includes implementation aspects. The continuing improvement at PLGS has resulted in mature processes that provide a systematic and integrated program to manage SSC degradation and ageing. However, it is apparent that the PLGS governing documents do not adequately or clearly describe how ageing is managed when compared against the IAEA/CNSC model. This is the second item identified for improvement in Section 3.1. The mapping of the PLGS processes using the IAEA model shown in Figure 2 provides a cursory illustration of how the two methods compare.

4. Path Forward

Based on the available information [1,2] about the likely contents of RD-334, the PLGS aging management program likely meets the intent of most of the new CNSC guidance. One exception is that the PLGS governing documents may not adequately meet the intent to demonstrate that ageing is managed in a systematic and integrated manner. This shortcoming introduces regulatory risk to PLGS operation. To reduce this risk, NBPN plans to prepare a document illustrating how PLGS processes will meet the new CNSC Regulatory Document RD-334. It is expected that the document will include:

- Criteria to identify all SSCs important to safety
- A description of the systematic and integrated ageing management approach at PLGS for all plant SSCs important to safety. It will identify the relevant management processes, high-level program documents, and organizational responsibilities.
- Key interfaces to coordinate ageing management activities.
- High-level performance measures to evaluate the effectiveness of the AMP.
- Sub-tier processes for SSC Selection and Evaluation for the AMP
  - Systematic process to identify all SSCs important to safety that may be susceptible to ageing degradation.
  - Documented process, criteria, and information sources used to determine whether the selected SSCs are susceptible to ageing degradation.
  - Process for AMP Review and Continuous Improvement
  - Description of the Data Collection and Record Keeping System to support ageing management
- Specific programs that are required to manage ageing and materials degradation of SSCs that are important to the safe, reliable, and economic operation of PLGS.

NBPN expects that improvements to the PLGS AMP may also be required to meet the intent of RD-334. Areas for improvements will be identified by a detailed gap assessment. Second, NBPN plans to identify industry best practices for implementation by performing benchmarking evaluations of European Utilities that have already retrofitted IAEA ageing management guidelines into their processes for extended operation. The general focus for improvements in the near term is on:

- The operations phase of the life cycle; PLGS is entering the period of extended operation so design, manufacturing, construction, etc. activities are minimal.
- Using existing processes, procedures, organization and by revising lower tier management documents.
- Extending the risk-based methods that were developed for the management of ageing and degradation for the PLGS HTS to the remainder of the plant.

5. Conclusion

NBPN is confident that the existing PLGS processes will be effective to manage ageing and to maintain the required safety functions for extended operation. The next steps are to document how current PLGS processes meet new CNSC guidelines and to identify any areas for improvement. Best practices will be used to implement improvements using OPEX from European utilities that have retrofitted IAEA guidelines for extended operation and PLGS experience in applying risk-based methods for ageing management. The current focus is to ensure good ageing management practices during the refurbishment outage and to implement improvements for post-refurbishment operation.

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Environmental Assessment Planning For Nuclear New Build In Canada

by D. Moffett[1], M.Mayhew[1] and J.Scongack[2]

[1] Golder Associates Ltd., Mississauga, Ontario

[2] Bruce Power PLC, Tiverton, Ontario

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Abstract

Bruce Power's planning process for maintaining or increasing the electricity generated at its Bruce County site includes refurbishing existing reactors and/or constructing new reactors. Successfully completing environmental assessments for refurbishment and new build projects is a key component of the planning process. Completion of an EA within a specified schedule presents particular challenges.

The paper describes how Bruce Power is addressing many first-time issues relating to an EA of a new nuclear power station, including: consideration of alternatives, number and design of reactors, cooling water and waste management strategies, and integration with existing facilities. In addition, the approach for successfully communicating with the local community and government organizations is described.

Introduction

In June 2006 the Ontario Government directed the Ontario Power Authority to proceed with developing a 20-year Integrated Power System Plan. In the directive, the government outlined its view of the future role for nuclear power in Ontario. Under the government's plan, nuclear power will remain a key source of Ontario's electricity by maintaining the installed nuclear capacity at 14,000 MW. In order to meet the government's policy framework, both refurbishment of existing facilities and building of new reactors needs to be considered as part of a long-term planning process by both the Ontario Power Authority and industry as a whole.

Bruce Power currently operates four nuclear reactors at Bruce B (Units 5 through 8), two nuclear reactors at Bruce A (Units 3 and 4), and is in the process of conducting a mid-life refurbishment on the two remaining Bruce A reactors (Units 1 and 2) and will also refurbish Units 3 and 4. Once the refurbishment at Bruce A is completed, Bruce Power can be expected to generate up to 6,200 MW at the Bruce Power site. However, the Bruce B station, which generates 3,200 MW, could require a mid-life refurbishment commencing around 2014. Although no decision has been made to refurbish any of the Bruce B units, an environmental assessment of the continued operation of the Bruce B station through approximately 2040 was completed in 2004 [1].

Consistent with the Ontario government's directive, Bruce Power is undergoing a multi-year planning process to evaluate its options for continued electricity supply over the long-term. Options being considered include refurbishment of existing reactors at the Bruce site or construction of new units to either replace existing units or augment output through construction of a third nuclear power plant at the site. This paper discusses the environmental assessment of approximately 4,000 MW of new nuclear capacity at the Bruce site. Consideration of a third station (Bruce C) would provide Bruce Power with the ability to plan for a wide range of options in maintaining the site as a major contributor to Ontario's long-term electricity requirements.

Table 1
Schedule of Key Milestones in EA Process

EA Process Step	Milestone	Timeline
Initiate Planning Process	Bruce Power announces plans for EA of new reactors at the Bruce site	0
	Bruce Power files Site Preparation Licence application	0
Initiate EA	Bruce Power files draft Project Description document	Month 1
	Bruce Power files final Project Description document	Month 5
	EA initiated by CNSC	Month 6
	Minister announces EA track decision (review panel)	Month 11
	CEAA announces participant funding	Month 11
Develop EA Scope	CNSC issues draft EIS Guidelines	Month 20
	CNSC issues final EIS Guidelines (anticipated)	Month 24
Conduct EA Studies	Bruce Power conducts EIS studies	Months 1 - 22
	Bruce Power releases draft EIS (anticipated)	Month 26
	Bruce Power completes studies and finalizes EIS	TBD
Complete EA Process	*Site Preparation Licence estimated 2009* *Construction Licence estimated 2010*	

Environmental Assessment Process and Schedule

An environmental assessment for a new nuclear power plant in Canada has been estimated to take 30-36 months to complete. This guessestimate of the schedule is based on the time taken to complete the assessments of other nuclear projects, including nuclear power station refurbishments and waste management facilities. This represents a major portion of the estimated 10 years it takes to plan and build a new nuclear reactor. In addition, an EA for a new nuclear power station presents three challenges:

First, on what "**track**" will the EA be conducted: comprehensive study or panel review? Our solution was to ask the Canadian Nuclear Safety Commission (CNSC) immediately to refer the project to a review panel.

Second, what is the **process** for completing the EA, including the process for the development and review of the draft EA guidelines, review of the EIS report and conduct of the panel review hearings? Because the Bruce New Build Project is the first such project in many years, there is considerable uncertainty with respect to the process steps, particularly in the early stages.

Third, what is the **schedule** for completing the EA, including key milestones such as completion of EA Guidelines and panel hearings? On other EAs, our approach to this challenge has been to develop an overall schedule in consultation with the CNSC. This has not been possible for this project, resulting in some uncertainty on when the EA might be completed.

2.1 Environmental Assessment Track

A review panel is widely accepted as being appropriate for a project of the magnitude and broad interest evident in a new nuclear power station. However, all projects assessed under the *Canadian Environmental Assessment Act* begin the assessment as a screening or comprehensive study. For example, the *Comprehensive Study List Regulations* identify that the proposed construction of a Class 1A nuclear facility that is a nuclear fission reactor that has a production capacity of more than 25 MW (thermal) as a project for which "*……the responsible authority shall ensure public consultation with respect to the proposed scope of the project for the purposes of the environmental assessment, the factors proposed to be considered in the assessment, the proposed scope of those factors, and the ability of the comprehensive study to address issues relating to the project and a comprehensive study must be conducted*".

A project on the comprehensive study track may be "bumped up" to a review panel on the recommendation of the responsible authority (RA), which is the CNSC in the case of nuclear projects. Alternatively, the responsible authority may recommend to the Minister that the EA continues on the comprehensive study track. Bruce Power, in agreement with several interested parties, asked that the Bruce New Build project be referred immediately to the Environment Minister for a panel review without going through a lengthy track report process. The Minister of the Environment accepted the CNSC's recommendation and referred the project to an independent review panel [2].

2.2 Environmental Assessment Process

In broad terms, the process for conducting the EA involves the following steps:

- EA initiation, including identification of RAs, decision on track and announcement of funding of interveners.
- EA Guidelines establishing the scope of the project and the scope of the assessment.
- Conducting EA studies and preparation of Environmental Impact Statement (EIS) by Bruce Power. The EIS is issued initially as a draft report.

Table 2
Reactor Design Considered in EA

Characteristic	PRESSURE TUBE REACTOR	PRESSURIZED WATER REACTORS		BOILING WATER REACTOR
	ACR-1000	AP1000	EPR	ESBWR
Manufacturer	AECL	Westinghouse	AREVA	General Electric
Country of origin	Canada	US	France/Germany	US
Number of Reactors Considered for New Build Project	4	3	2	2
MW(e) net per reactor	1,085	1,090	1,600	1,535
MW(e) net for Project	4,340	3,270	3,200	3,070
Design Status	New Design	New Design	Being Built	New Design
Maximum fuel enrichment (^{235}U %)	2.5%	5%	5%	4.2%
Design Life	60[a]	60	60	60
Notes: [a] Requires mid-life refurbishment				

- Establishment of review panel and procedures.
- Panel review and hearings.
- Panel recommendation.
- Decision on EA by Cabinet.

A positive decision is required to allow CNSC and other RAs to proceed with decisions on licence and permit applications.

While the elements of this process are common to many projects subject to review panel, their implementation on a new nuclear power plant project is new. In addition, the requirements for consultation with local First Nations are being worked out on a case-by-case basis and have been more complex than expected. The absence of a clear process with firm guidelines is a major risk to the timely completion of the environmental assessment. For example, the time between the acceptance of Bruce Power's Project Description document and the issuing the draft EA Guidelines is at least 15 months. In addition, there has been some uncertainty with respect to the roles of the CNSC, other RAs and the Canadian Environmental Assessment Agency (CEAA). Future proposals should benefit significantly from the clarification of the process that should result from completion of the Bruce New Build project EA.

2.3 Environmental Assessment Schedule

As indicated above, the schedule for completion of each of the major milestones in the EA represents the greatest challenge to the timely completion of the EA. Schedule slippage throughout each of the steps is often beyond the control of a proponent and results in a major risk that must be managed if the planning process is to be completed within an appropriate time.

Table 3, below, shows the schedule for the major milestones of the Bruce New Build project EA as it stood in March 2008 when this paper was prepared. As noted in the table, the schedule for completion of the EA is not known. Uncertainties in the time required to complete the assessment are more likely to occur because of the process issues rather than the time taken to complete the EA studies or preparation of the EIS.

3 Bruce New Build Project Description

A fulsome description of the Bruce New Build project is required to allow the conduct of the assessment of effects. The assessment of effects is based on a description of the project during its site preparation and construction, operation and maintenance, and decommissioning phases. To allow this assessment, the constituent principal project works and activities that make up the various phases of the project are described using information supplied by the reactor vendors, supplemented by experience elsewhere as reported in the literature. Project works and activities include the various physical structures, buildings, systems, components, activities and events that make up the project. Each project work and activity is described in sufficient detail to enable the EA study team to determine how it might individually, and collectively with other project works and activities, affect the existing environment during normal operations or as a result of malfunctions and accidents.

Developing a suitable description of the project that would serve as the basis for the environmental assessment presents three significant challenges:

- First, how many reactors, including both refurbished and new units, would be operating at the Bruce site within the next 20 years? Bruce Power is currently proceeding with the refurbishment of Bruce A (4 Units), the refurbishment of Bruce B (4 Units) is under consideration, and a third station may include up to four units. Our solution to this challenge was to develop a **maximum project concept**.
- Second, at the time the environmental assessment was initiated, Bruce Power and the province had not decided on a spe-

cific reactor design. This represents a significant challenge to conducting the EA since different reactors may have different interactions with the environment. Our solution to the challenge of conducting a "technology neutral" EA was to develop and characterize a **generic plant envelope**.

- Third, an environmental assessment under the *Canadian Environmental Assessment Act* requires consideration of alternative means of carrying out the project. In addition to alternative reactor designs, alternative means for the project may include different combinations of siting location, cooling water approach, switchyard design, and used fuel and waste management options. Our solution to identifying and evaluating alternatives to the project was to develop a **reference project.**

3.1 Maximum Project Concept

The Bruce New Build project is defined by a series of alternatives for generating approximately 4,000 MW of new nuclear power. To ensure a conservative approach, the assessment of effects uses bounding scenarios for the duration of the project. A bounding scenario is defined as the situation where the predicted effects may reasonably be expected to be greater than all other likely scenarios. If no significant adverse effects are predicted using the bounding scenarios, it is valid to assume that there will not be any significant adverse effects during all other normal conditions.

For planning purposes, the EA assumed a **maximum project concept** that assesses the effects of up to 12 reactors, comprising the eight existing units and up to four additional new units. This would increase the total generating capacity of the site to approximately 10,000 MW. Accordingly, the environmental assessment would consider the effects of the new nuclear generating capacity cumulatively with the existing effects of 6,200 MW of capacity from Bruce A and Bruce B. This approach provides Bruce Power with flexibility in its planning process by allowing the company to consider a full suite of refurbishment and new build options for the site.

3.2 Generic Plant Envelope

At the time of initiating the environmental assessment, Bruce Power was considering five potential reactor designs. The ACR-1000 and Enhanced CANDU 6 (EC6) are the latest models of pressurized heavy water reactors offered by Atomic Energy of Canada Ltd. (AECL). The Westinghouse AP1000 and the Areva U.S. EPR are the two of the latest generation of pressurized water reactors (PWR). The General Electric (GE) ESBWR represents the latest generation of boiling water reactor (BWR). Consideration of a "technology neutral" environmental assessment incorporating all of the possible reactor designs is identified as one acceptable approach by the CNSC [3].

The information used to describe the generic plant envelope is based on publicly available information and therefore, consists of a range of level of detail. Similar information is not necessarily available for all reactors at the same level of detail. The level of detail, however, must be sufficient to define the generic plant envelope to a level appropriate for an environmental assessment. Consequently, the EA refers to generic plant parameters for the reactor and its associated facilities. For each parameter required for the EA studies, the most conservative of the reactor designs is used in the generic plant envelope. This approach allows Bruce Power to assess the environmental effects, including the environmental benefits, of each reactor design while at the same time ensuring that the assessment of effects is conservative and does not add unnecessary complexity to the EA.

Since initiating the EA, the Ontario Government announced in March 2008 that it was seeking competitive bids from four reactor manufacturers: the ACR-1000, the U.S. EPR, the AP1000 and the ESBWR. Accordingly, it was decided that the EC6 will no longer be considered as a potential reactor design for the Bruce New Build project. A summary of the technical specifications for each of the reactor designs is provided in Table 2.

3.3 Reference Project

It is common practice in planning for a project of the scale proposed by Bruce Power that alternative means of accomplishing the project are identified and assessed. The Bruce New Build project could be achieved by a variety of combinations of these alternative means. One purpose of the EA is to identify the environmental effects of the various alternatives for achieving approximately 4,000 MW of new nuclear capacity at the site. In addition to the four reactor designs, the alternative means for the Bruce New Build project considered in the environmental assessment include the following:

- Three alternative locations on the Bruce site;
- Two cooling water strategies, involving recirculating and once-through water cooling;
- Two switchyard designs comprising alternative technologies; and
- On-site and off-site radioactive waste management strategies.

To simplify the comparison of alternative means, one set of alternatives was identified to form the Reference Project. The Reference Project identified for the EA includes a credible bounded generic reactor design, a site option adjacent to Bruce A, a once-through cooling water strategy that is common to all existing Canadian reactors, on-site radioactive waste management systems consistent with current practices at the Bruce site, and a state-of-the-art switchyard design that provides maximum flexibility with respect to power plant layout.

Other sets of alternatives are combined to form Alternative Project Scenarios that can be compared directly with the Reference Project. This approach enables the EA to be conducted with a clearly defined set of parameters by fully assessing the project's anticipated environmental effects from the beginning of the EA process to the end, thus improving efficiency and lending clarity to the process.

Following identification of the Reference Project, each of the alternative means is introduced to the EA process as a clearly defined Alternative Project Scenario, and the additional or different effects are assessed relative to the Reference Project.

4. Cooling Water Options

Approximately two-thirds of the thermal energy generated in a nuclear reactor is discharged to the environment. Previous EAs of nuclear power stations in Ontario have identified this

Table 3
Comparison of Condenser Cooling Water Alternatives

Characteristic	Once-through Cooling	Mechanical Draft Cooling Towers
Energy penalty or gain relative to once-through cooling (%)	0	-3
Maximum heat load to Lake Huron (MW)	8,460	98
Maximum heat load to atmosphere (MW)	0	8 ,60
Condenser cooling water flow rate (m^3/s)	220	130
Maximum acceptable condenser inlet water temperature (˚C)	23.2	30
Maximum acceptable condenser outlet water temperature (˚C)	32.2	45.6
Maximum lake water temperature increase (˚C)	11	0
Maximum acceptable discharge water temperature (˚C)	32.2	32.2
Discharge (blowdown) flow rate – CCW (m^3/s)	220	0.9
Discharge (blowdown) flow rate – Service water (m^3/s)	30	0.12
Evaporative losses flow rate (m^3/s)	0	3.7
Make-up flow rate (m^3/s)	0	4.6
Land area for condenser cooling water system (m^2)	0	156,000

discharge of heat as one of principal effects on the biophysical environment. The means of achieving the necessary removal of heat are the use of recirculating cooling or once-through cooling system using lake water. Several alternative technologies to achieve these two approaches have been evaluated as part of the EA, including using natural or mechanical draft cooling towers. The options of mechanical draft dry cooling towers and natural draft cooling towers were determined not to be feasible.

The alternative means considered for the project include:

- **Mechanical Draft Cooling Towers.** These include cooling tower banks and re-circulation of cooling water. Heat is dissipated through evaporation and direct transfer of heat to the atmosphere. In addition, mechanical cooling systems involve an energy penalty compared with once-through systems.
- **Once-Through System.** This includes a once-through water intake with pumping system that takes and discharges water to Lake Huron, similar to that currently used at Bruce A and Bruce B. The state-of-the-art for once through systems involves both submerged intakes and discharges.

4.1 Mechanical Draft Cooling Towers

Cooling towers dissipate heat through evaporative losses to the atmosphere. The movement of air though these towers is mechanically induced by fans. Mechanical draft cooling towers require the use of large fans, which typically consume about three percent of the electricity generated by the station.

4,000 MW of new nuclear generation would require at least 20 blocks of mechanical draft cooling towers. Each block would be divided into nine towers each with a top mounted fan. Each block would be approximately 180 m long, 18 m wide, and 14 m high, including the fan stack. The total footprint for a cooling tower for 4,000 MW of electricity generating capacity would be about 6 hectares (ha).

This is the first time mechanical draft cooling towers have been considered for such a large nuclear power station in Canada. While they offer a considerable benefit in reducing water demand, the adverse effects of fogging and icing, noise and amount of land required are important considerations in the EA.

4.2 Once-Through Cooling System

A once-through cooling system comprises a cooling water intake system and a discharge system, which typically draw from and discharge to a large body of water. Subsurface systems are typically preferred from an environmental perspective and have better access to cold water.

4,000 MW of new nuclear generation would require approximately 220 m^3/s flowing through the plant. This flow can be supplied by two concrete lined tunnels with an internal diameter of 7.5 m, resulting in a velocity of about 2.25 m/s. This velocity is high enough for the tunnel to be self-cleaning while keeping head losses down. The velocity cap for such an intake system would require a diameter of approximately 30 m and a height of 6 m resulting in flows of about 0.2 m/s at the outer edges of the cap. The flow into the velocity cap should be horizontal to allow most fish to avoid becoming captured by the system.

Based on the conceptual layout of the intake and discharge tunnels for the project at two alternative locations on the Bruce site, the length of the intake tunnels could be up to 1,600 m to ensure a water temperature in the 5˚C to 10˚C range in the summer. The depth of the centreline of the tunnels would be 40 to 45 m below lake water level. The length of the discharge tunnels could be up to 1,100 m to ensure that the cooling water is discharged in at least 9 m of water. The depth of the centreline of the tunnels would be 40 to 45 m below lake water level.

Cooling water would be discharged through a series of dif-

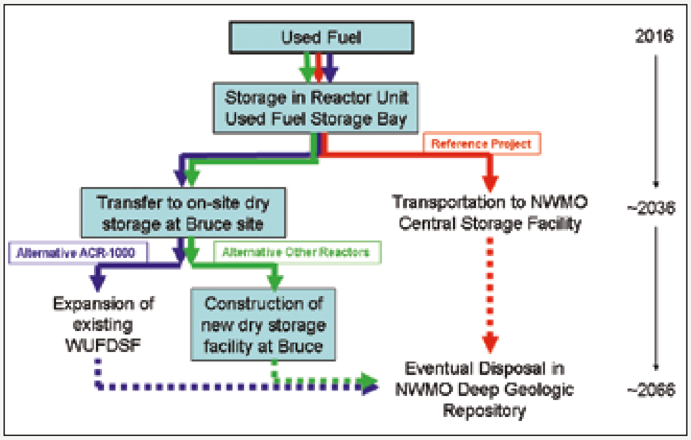

Figure 1 Alternative Means of Used Fuel Management

fusers attached to the crown of the discharge tunnel, and the first diffuser would be located at the 9 m depth contour line. The velocity at the outlet port of the diffusers is set at of 3 m/s. Larger velocities at the nozzles improve dilution but cause an exponential increase in head losses and associated pumping costs, and may impact the fish in the vicinity of the structure. The spacing between the diffusers is a function of the thermal dispersion. A diffuser with a nozzle diameter of 2 m would require 12 diffusers at about 20 m centre to centre at an exit velocity of 3 m/s to accommodate the system flows.

Table 3, below, presents a summary of the condenser cooling water options assessed in the EA. As mentioned, this is one of the major areas of interaction between the power plant and the environment. The choice between once-through cooling systems and mechanical draft cooling towers involves a balance between the energy penalty and the environmental effects of the thermal discharges to water. It is worth noting that many of the negative perceptions of nuclear power are associated with natural draft cooling towers.

5. Radioactive Waste Management Strategies

One frequently asked question throughout the EA public consultation process relates to the management of radioactive wastes from the project. This includes the management of both used fuel and intermediate- and low-level wastes. The following sections briefly describe the alternative waste management strategies being considered in the EA.

5.1 Used Fuel

The operation of any nuclear reactor generates highly radioactive used fuel. A used fuel bay, located adjacent to the reactor, is a deep water-filled pool and is used for interim storage of spent fuel. The fuel is stored in racks that allow adequate cooling of the fuel and ensure that the array of fuel elements remains subcritical. The purity of the water in the used fuel bay is maintained by ion exchange treatment. The temperature of the water is maintained by circulating it through heat exchangers.

Current practice in Canada is for used fuel to remain on-site, in the used fuel bay for a period of up to 20 years prior to being transferred to dry storage. There are currently three used fuel dry storage facilities in Ontario, which include one each at Bruce, Pickering and Darlington sites. All of these dry storage facilities are designed to safely store CANDU used fuel generated at the respective sites for a period of several decades. The federal government has mandated the Nuclear Waste Management Organization (NWMO) with the responsibility for identifying and siting facilities for the long-term management of Canada's used nuclear fuel. Depending upon the progress made by the NWMO in establishing a centralized repository, several options are considered for the interim management of the used fuel from the Bruce New Build project:

Extended **wet storage** at the Bruce site until a NWMO repository is available (assumed to be approximately 20 years). A period of approximately 10 years is required to allow the used fuel to cool.

Transfer of used fuel to a **dry storage** facility at the Bruce site. OPG currently operates a used fuel dry storage facility at the Bruce site for used fuel from the Bruce A and Bruce B stations.

The EA considers both the storage of used CANDU fuel bundles from the ACR-1000, and the larger fuel assemblies used by light water reactors (AP1000, EPR and ESBWR). The scenarios considered in the assessment are shown in Figure 1, which identifies the two possible dry storage options that depend on the choice of reactor design.

5.2 Low and Intermediate Level Radioactive Waste

Dry solid wastes consist of air filters, miscellaneous paper, rags, solid laboratory wastes, contaminated clothing, tools and equipment that cannot be decontaminated. These wastes are typically low level and are subdivided into compactable and non-compactable waste. Compactable waste is compressed in bundles for storage. Non-compactable waste is stored in metallic containers and drums.

Intermediate level wastes include spent ion exchange resins and filters resulting from the removal of radioactivity from the fluid of various systems. In addition, the treatment of liquid wastes by filtration and reverse osmosis generates solid wastes.

The EA is considering two alternatives for the interim management of the low- and intermediate-level radioactive waste as shown on Figure 2. It is assumed that when a long-term management option is available, the wastes would be transferred to that facility. Currently, OPG is planning to construct a Deep Geological Repository at the Bruce site for waste that is currently stored at its Western Waste Management Facility (WWMF), which is also located at the Bruce site.

6. Stakeholder and Community Consultation

A key component of the EA process is undertaking public consultation and communication activities, particularly for a project that garners as much public and media interest as a

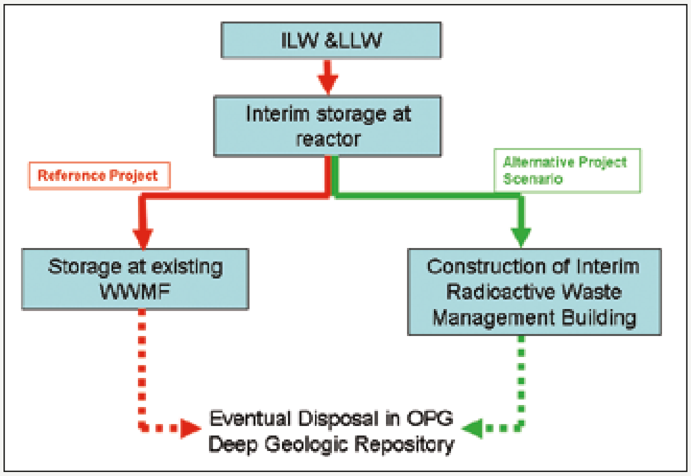

Figure 2 Alternative Means of Intermediate and Low Level Waste Management

nuclear new build. Indeed, strong community support for the project is recognized by both Bruce Power and the provincial government as essential for successful project implementation. Comments and questions received throughout the consultation process are an integral feature of focussing EA studies, especially those relating to the socio-economic effects of the project, and will ultimately assist Bruce Power and the provincial government in their decision making processes.

Designing and conducting an effective and meaningful consultation and communication program presents two main challenges, which are exacerbated by the uncertainties in the project:

- First, identifying all the stakeholders that should be included in communications and determining how best to communicate project information and solicit feedback from individuals and groups with varying consultation needs and expectations. Our solution is to develop **targeted communications plans**.
- Second, engaging the provincial and municipal agencies that are responsible for identifying and implementing socio-economic policies and programs that could be affected by the project. Our solution is to use **action focussed information exchanges**.

6.1 Targeted Communications Plans

Bruce Power is committed to providing all stakeholders with opportunities to gain knowledge about the Bruce New Build project, and to provide input to the EA studies. Two specific communication plans are used to achieve this commitment, namely:

- Bruce New Build Project EA Communications and Consultation Plan.
- Bruce New Build Project EA Non-governmental Organizations Communication Plan.

The first of these communication plans describes specific activities to consult with federal, provincial, and local government agencies, communities near the Bruce site, Bruce Power employees, and the general public. Activities include public open house events, workshops on specific topics (e.g., Valued Ecosystem Components), regular updates of information on a project-dedicated website, and postage-paid reply mailcards inviting the public to join the project mailing list. To date, the project mailing list includes over 500 individuals and organizations who receive on-going communications related to the project. The communication plan is designed to keep information

Table 4
Summary of Main Concerns Identified Throughout Consultation Program

Identified Concern	Typical Issue Addressed in EA Studies
Housing	Competition for rental accommodation and affordable housing between local residents and in-movers during construction
Traffic	Increasing traffic congestion on roadways leading to the Bruce site
Radioactive Waste Management	Considering two strategies for the interim management of used fuel: 1. Extended wet storage and transfer to NWMO repository by 2035 2. On-site dry storage
Capacity of Social Services	Additional pressures on the availability of healthcare services and support
Equity of Taxation	Distribution of taxes paid on behalf of Bruce Power to the Municipality of Kincardine (the host municipality), the County of Bruce, and the school boards
Nuclear Accidents	Confidence that the most severe accidents are identified and assessed to provide assurance of public safety
"The CANDU Advantage"	Conducting a technology neutral EA may not acknowledge public preferences for the proven and accepted Canadian technology
Paying for the Project	Confirming that Bruce Power's investors are responsible for providing the capital investment to undertake the project
Transmission	Acknowledging insufficient transmission if electricity generating capacity of Bruce site exceeds 6,200 MW

on the project highly visible in community and to provide ample opportunities for face-to-face interactions between community members and senior management at Bruce Power.

Following each communication event, a formal report is produced that summarizes the focus of the discussions and documents every comment or question relating to the project or the EA process to ensure it is addressed. The main concerns identified throughout the consultation program thus far are summarized in Table 4. In each case, the goal is to build consensus on issues to be addressed by the EA studies.

Non-governmental organizations (NGOs) are identified as one important category of stakeholders. One of the primary objectives described in the NGO Communication Plan is to determine how and when NGOs are given the opportunity to comment on the EA studies. To satisfy this objective, profiles of local, provincial/national and U.S.-based NGOs that may be interested in the project are developed, and each NGO is contacted to gauge their interest in receiving project information and participating in a workshop tailored to meet their needs. An NGO workshop was organized, and participants were invited to attend sessions that highlighted their specific interests including radioactive waste management, security considerations, malfunctions and accidents, and climate change. The comments and questions raised by NGOs at the workshop are reviewed by the EA study team and are addressed in a workshop report and the EA.

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The Latest Application of Hitachi's State-of-the-art Construction Technology and Further Evolution Towards New Build NPP Projects

by Kenji Akagit[1], Kensuke Morita[2], Ryohei Miyahara[3], Kouichi Murayama[4], Christopher Deir[5] and Shiro Akahori[6],

[1234] Hitachi-GE Nuclear Energy Ltd., Hitachi-shi, Ibaraki, Japan

[56] Hitachi Canada Ltd. Power & Industry Division, Mississauga, Ontario, Canada

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Abstract

Shika Nuclear Power Station Unit No.2 began commercial operation in March 2006 as one of the latest new-build projects in the world. Hitachi-GE Nuclear Energy Ltd. (Hitachi) was the main contractor and supplied the entire plant including engineering, manufacturing of all major reactor and turbine-generator components, and executed the installation and commissioning. Hitachi completed the project on schedule and on budget owing in large part to its highly reliable advanced construction technology.

This article describes Hitachi's unsurpassed advanced construction technology being applied to the current new-build projects in Japan. Furthermore, this article addresses a possible form of applications to new build Nuclear Power Plants in North America.

1. Introduction

Since the first nuclear plant was constructed in Japan in the 1960's, fifty-five nuclear power plants have been built, and one more plant is currently under construction by Hitachi. Hitachi has constructed twenty-two nuclear power plants (NPPs) in Japan to date, and has played an active role in the field of nuclear power plant construction. Hitachi's advanced technologies, such as a unique 3D-CAD based integrated plant engineering environment and streamlined design-to-manufacturing systems have been successfully implemented in past NPP projects.

Over the last few decades, the plant construction environment has changed in Japan dramatically. For example, the pool of construction workers has gotten smaller and smaller, while the average age of workers has increased. Moreover, customer demands for costs reduction and shorter construction periods continued to become stronger. Therefore, achieving greater rationalization in construction is one of the most important issues in power plant business.

To meet these demands, Hitachi has developed construction strategies based on the abundant feedback gained from NPP construction experience and has made great strides in the rationalization and application of this feedback into its strategies. The strategies are very simple in principle, however, their effectiveness has been absolutely proven through the successes of the past projects. In addition, Hitachi believes their strategies are equally applicable to any and all power plant projects, including CANDU.

Utilizing all of Hitachi's accumulated technology, one of the worlds latest new-build projects, Shika Unit No.2 (Shika-2) of Hokuriku Electric Power Company with 1,358MW electrical rated output, was constructed "On-Budget and On-Schedule".

The Shika-2 was the first ABWR plant in which all the major equipment, including the reactor, turbine and generator, were supplied and constructed were provided by one main contractor, Hitachi. As well, Hitachi took responsibility for the entire plant engineering support from the basic design through to commissioning. The construction started with the foundation excavation of the main building in September 1999, and 58 months following rock inspection, the plant was declared in commercial operation.

This paper describes the latest technology that Hitachi applied to the design and construction of this plant and which are being further enhanced at the current project in Japan.

2. Applied Construction Technologies

In the construction of Shika Unit No.2, the following strategies were employed.

(1) Broader application of large module/block construction methods
(2) Open-top and Parallel Construction method
(3) Application of floor packaging construction methods
(4) Full application of information technology to quality plant engineering and construction achievements

As a result, there was an approximately 25% reduction in the peak work load at site achieved due to these improvements to construction procedures in work areas where many construction tasks take place operated were implemented.

From the next paragraphs outlines the methodology and technology used to accomplish this reduction.

2.1 Broader application of large module/block construction method

Large module/block construction method is one of Hitachi's construction strategies. This method utilizes heavy-lift crane to lift and install large scale modules/blocks which can be constructed at either site or a module shop.

Hitachi has employed this method since the early 1980's to the construction of nuclear power plants, with a total number of about 900 modules experienced so far. During the design, a Computer Aided Engineering (CAE) system is fully deployed with special features dedicated to a specifically for module engineering (such as automatic center of gravity calculation and assembly planning). Hitachi routinely applies this specialized CAE systems to the overall module engineering, and constructed a dedicated module factory in 2000 which is fully integrated with the CAE system. By making the best use of these assets, about 200 modules were designed and built for Shika-2. The figure 1 shows an example of a large scale module (RCCV upper drywell module) which consisted of pipe whip restraint structure, radiation shielding, piping, valves and other components in the drywell, totalling 650 metric tons.

Another example is the main steam tunnel modules (55 metric-tons each) which were fabricated with special features that minimize weld edge preparation and simplifies installation and connection work by employing 3-dimensional data measurement feedback from the site. Thus, Hitachi applied modular/block construction method at large scale, and been continuing sophisticating their technology for future plants.

Figure 1 RCCV Upper Drywell Module

2.2 Open-top and Parallel Construction method

"Open-top and Parallel-Construction method" is often applied to NPP construction in Japan now, and it was applied to Shika-2 without hesitation. In the most basic aspects, in this method construction work of both civil and mechanical disciplines are conducted in parallel with mutual agreements of scope of work, and major components to be installed in the area are carried in prior to the ceiling work of that area being installed. After the curing of concrete in the ceilings and walls, the installation work within the target area starts. At the same time, major components are brought into the upper floor level. Thus during the construction of the building civil structure, mechanical/electrical installation work can proceed which therefore, enables a levelling off of manpower peak at the construction site. As one may expect, since various activities are implemented at the same time, this method requires very detailed coordination between civil contractors and mechanical/electrical installation companies including delivery control of components.

2.3 Application of floor packaging construction method

Traditionally, hydro-static pressure testing in completed power plant systems needs to be implemented after the completion of system construction, which inevitably led to work loads peaking at or near the end of construction. Hitachi has developed a new

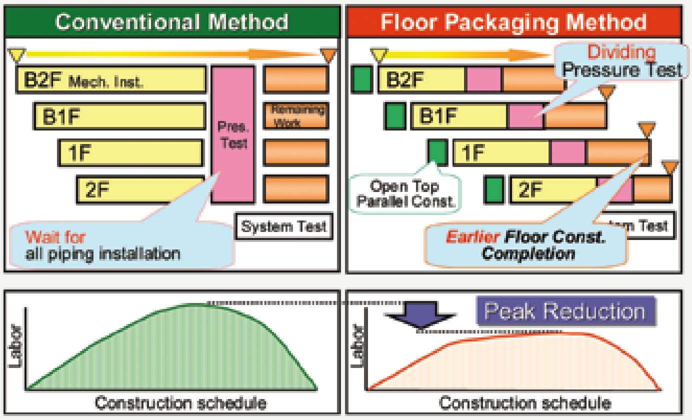

Figure 2 The concept of Floor Packaging Construction method

As shown within this figure, with the conventional construction method hydro-static pressure testing starts only once until system construction in all floors is completed, even if installation is completed in the lower floors. Implementing partial hydro-static pressure testing in each floor before completion of whole system construction makes it possible to distribute the work before hydro testing, and levelling off of the workload peaks.

concept for this issue, named "Floor Packaging method", which allows partial hydro-static pressure testing prior to completion of whole system construction. Figure-2 shows the concept of the method. After completing construction in each floor, the partial pressure testing is undertaken in the range of closed area. Therefore, the work area can be sequentially closed from the bottom floor, which helps a great deal of levering off the maximum workload.

2.4 Full application of information technology to quality plant engineering and construction achievements

(1) Application of Advanced Technology and 3-dimensional CAD over the complete plant design and work plan

Hitachi has applied Computer-Aided-Design using the latest computer technology to the plant arrangement and layout design for Shika-2. By fully applying an improved system compared with the previous power plant designs, more sophisticated plant and piping layouts were enabled. For example, the advanced CAD system allowed engineers to more easily allocate adequate operational space, equipment disassembly space, and temporary storage space for equipment. (Ref. Fig. 3) Furthermore, the CAD system made it possible to simulate machines disassembly and inspection during the design phase. This feature resulted in centralization of plant data information management, improving the advance work plans for inspection, and allowing engineers to identify interferences between components during construction. (Ref. Fig. 4)

The application of this advanced CAD system made the plant layout design more efficient and accurate. In addition, its simulation function helped leverage practical engineering for accessibility, constructability and maintainability. Simulations also made it easier to confirm the transport paths of disassembled equipment and to examine the transport procedures. From a variety of different perspective, quality design and highly efficient work were achieved.

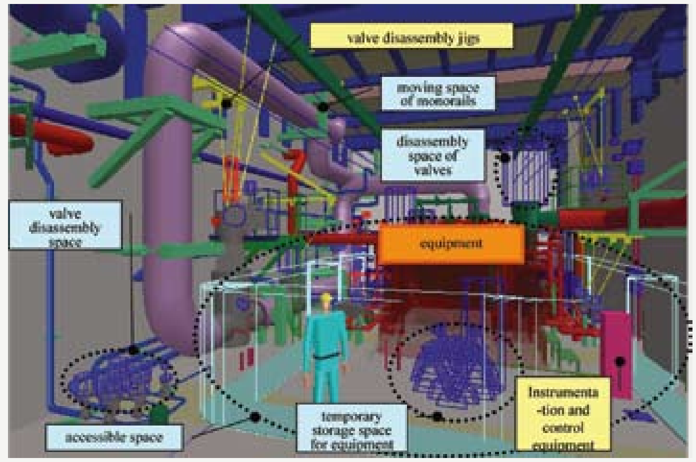

Figure 3 Examination of area layout

This figure shows the examination of the area layout, with inspection space and equipment disassembly space, using 3D-CAD. This kind of simulation made it possible to plan rational layout during the design phase.

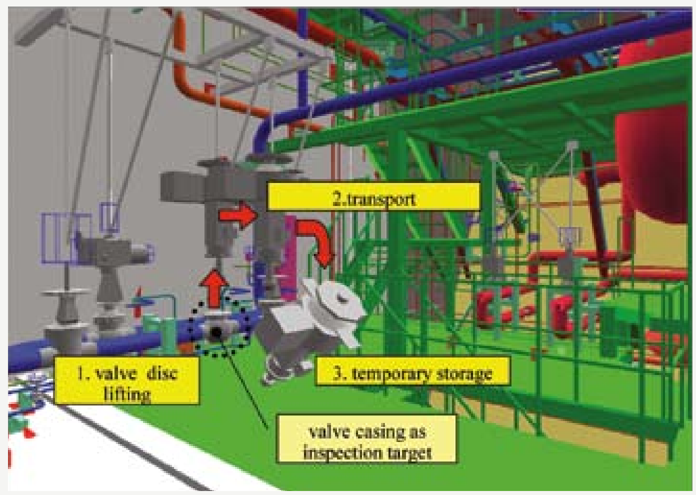

Figure 4 Examination of equipment disassembly simulation

Using 3D-CAD makes it possible to visualize the work-procedure and to detect the interferences between components under installation.

(2) Establishment of a local network

In order to fully utilize the quality plant engineering data received from the construction site, the information needs to be shared among main project participants appropriately and rapidly. For Shika-2, engineering offices, manufacturing facilities, and site offices were connected by computer network, and the site office was directly connected to each major satellite construction area for high-speed interactive communication. The network

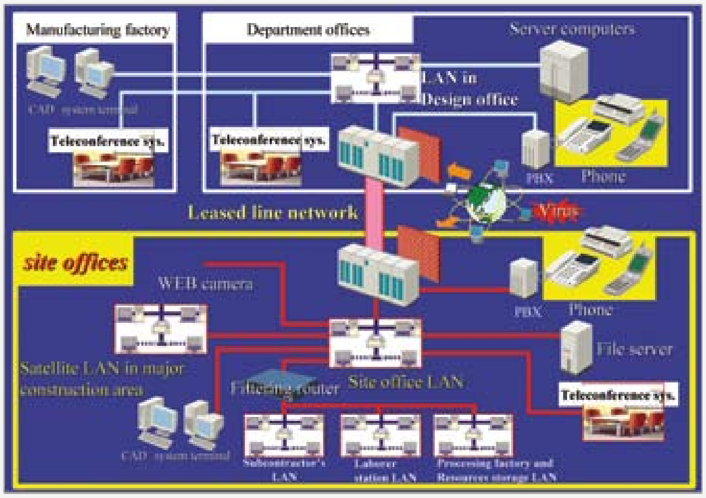

Figure 5 Structure of network facility

This figure shows the structure of the network between engineering offices, site offices, and site.

made it possible to communicate and download any design information at the satellite construction sites. (Ref. Fig. 5)

(3) Development and Introduction of an integrated construction management system (ICMS)

During the construction period of a nuclear power plant, nearly countless equipment and components need to be well managed. Therefore, detailed planning takes place before the actual work commences, ensuring on-time delivery of products and documents and early acknowledgement of any discrepancy between plans are very important. To support and ensure this works properly and timely, Hitachi has been developing and perfecting an advanced site construction management system since 1996. This system enables not only the ability to share the engineering information and documents but also to store computerized construction records and other important data. As well as this, for Shika-2, additional key features, supporting the turnover and commissioning of systems were added. This system now covers the entire construction work at site. Thanks to this integrated system, highly efficient and quality construction work is achieved.

3. Development of Advanced Technologies

Hitachi is currently constructing new-build projects in Japan now. For this project, more advanced technologies beyond those applied at Shika-2 are developed and introduced. Application of RFID (Radio Frequency IDentification) is one of more advanced technologies. RFID is a technology which allows contactless recognition to obtain the information stored in the integrated circuit using an electronic reader and transmitter, and it has more advantageous features than barcode, which include better anti-counterfeit features and invisible recognition.

For NPP construction, it is imperative that precise and accurate traceability methodology are employed required, therefore significant manpower were traditionally spent at every project for this purpose. In the aim for more efficient and quality construction work, a more rational, less labour intensive strategy was required.. Therefore, by utilizing the RFID key features, Hitachi initiated the development and application of RFID systems to NPP construction. In this section, some of the application plans for RFID are described.

(1) Application to Product Control Subsystem

Conventionally, product was shipped from factory with an identification label on product and added to a shipping information list for use at site. On the arrival of the products at site, a work foreman would identify those products by checking the label attached on the products and comparing the information to that contained on the shipping list, and then manually record the results into the database as to which components had been delivered to site. This required a lot of time and effort to ensure product management.

In the newly developed system, product labels contained RFID are attached to the product at factory, and the product ID and RFID number are automatically linked to the database system. The work foreman can now easily identify products by reading the RFID information using a handheld reader, and the result can be transferred to the database. In order to apply RFID to NPP construction, significant research and studies were performed to ensure the RFID technology would operate as excepted under the extreme environmental conditions which could be present at a construction work site.

(2) Application to Construction Work management

Piping at its construction work site is typically managed by the relevant welding points, and the work record would be manually prepared and input to the database. For the improvement of this process, Hitachi also applies RFID technology to the welding process. With the newly developed systems, work instruction can be obtained by just pointing a PDA with a reader to the RFID on the piping to be welded, and the work records can be easily input via PDA adding worker ID and tool/instrument ID (which are also identified by their associate RFID). As well as improvement of the preparation of work record efficiency, this has led to a decrease in human errors in recording work completion and allows for rapid updates to work progress reports.

4. Application to new-build CANDU's in Canada

(1) Requirements from Canadian Nuclear Market

Amid the "Nuclear Renaissance", both Canada and Japan are two markets which have been maintained keen interest in building new reactors. Japan has been seeking the best lessons learned from other advanced countries, including Canada, with regard to management of nuclear construction issues. Canada and Japan have similar issues to be resolved in furthering nuclear development, such as safety, public acceptance, aging reactor fleets and need for new-construction to accommodate economic growth. Japan has observed the global nuclear performance and believes that the CANDU fleet in Canada is one of the best benchmarks for Japan to follow based on its high capacity factor and other outstanding operating records. In return, Japan is convinced that it can be used as an example for the Canadian nuclear industry by sharing and exchanging its expertise and experience, particularly, in the area of new-build project execution and construction, based on its over-30-year period of uninterrupted construction activities. Focusing on new-build projects execution, Canada has not had a new-build projects in place since the completion of the Darlington Nuclear Generating Station in early 1990's, while Japan has completed 4 ABWR projects with one other under construction. However, despite the recent experience of new-build projects implementation, other priority issues are basically the same toward successful deployment of new reactors. Some examples of major issues are listed below:

- Need to shorten overall project schedule, in particular, duration of site construction,
- Diminishing and in-demand pool of skilled trades,
- An aging labor force in the areas of engineering, manufacturing and construction,
- Reduced supply chain capacity.

To overcome these facts and then to allow the successful launch of new-build projects, one of the most practical approaches is to utilize and mobilize advanced techniques such as Hitachi's advanced construction technology which have been tested and proven time and time again via new-build projects implementation in Japan. The advanced construction technology minimizes the impact of traditional bottlenecks at during site construction while facilitating standardization.

(2) Path Forward for Applications to New-Build CANDU in Canada

Localization is one of the key issues which leads new-build projects to success. Putting aside aspects of socio-economic, the following points have to be addressed for successful implementation/completion of new-build projects:

- Securing a sustainable group of skilled trades,
- A Robust local supply chain, particularly for ancillary components and bulk material (Piping, Cable, Valves, Raceway, etc.),
- Identifying capable local engineering/manufacturing vendors and/or partners,
- Ensuring transportability of large-scale major components and modules by having local manufacturing vendors and/or partners with suitable locations

Localization is one of Hitachi's challenges as its experience and expertise are based on its successful execution of new-build project in Japan. Hitachi has been working closely with AECL to be ready for deployment of new reactors in Canada for a decade. Hitachi and AECL have been in full agreement in utilizing/optimizing capability at both ends to yield synergy and complementary skill sets. Further, advantages from Hitachi's advanced construction technology can be maximized where Hitachi and local construction companies pull together. On this point, Hitachi is confident that it can achieve this goal by exercising its relationship with AECL and other local partners. Hitachi is also convinced that Canadian local companies will be able to utilize Hitachi's advanced construction technology which has already proved to be most beneficial for new-build projects.

5. Conclusion

This paper describes Hitachi's achievements for Shika Unit No. 2 of the Hokuriku Electric Power Co including various advanced construction technologies. In addition, more advanced construction technology being applied to the upcoming new-build projects in Japan is also described.

Although Hitachi's technology and experience have been cultivated through BWR projects, their practical engineering capability and methodology can be equally applied to CANDU projects. Against the background of great interest in nuclear energy in Canada, AECL and Hitachi, along with its subsidiary Hitachi Canada, Ltd, have started sharing each other's unique and extensive capabilities for new build CAND projects.

Hitachi is confident that it can contribute to execution of new-build CANDU projects in Canada by exercising relationship with AECL and other local partners. Hitachi is also convinced that Canadian local companies well appreciate Hitachi's advanced construction technology which is already proved to be most powerful tool for new-build projects construction/implementation.

Hitachi is committed to the endeavour for further development of advanced construction technology and to provide more economical, safe, and reliable nuclear power generation systems to the Canadian market as well as all over the world in the coming nuclear renaissance.

6. Acknowledgement

In developing and applying Hitachi's construction strategies and technologies, Hokuriku Electric Power Company helped and inspired our achievements. We sincerely appreciate the cordial help of Hokuriku Electric Power Company with good faith.

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GENERAL news

Ontario chooses Darlington Site for "new build"

On June 16, 2008 the Ontario Ministry of Energy and Infrastructure Ontario announced the selection of the Darlington site of Ontario Power Generation as the location for two new nuclear plants. Ontario Power Generation applied for an Environment Assessment and Site Approval last fall, which was referred to an EA Panel. However, that panel has not yet been appointed.

It is understood that transmission capacity was the primary factor in favour of the Darlington site. Hydro One has an application with the Ontario Energy Board for an enhancement of the Bruce to Milton transmission line.

Municipal officials in the Durham region welcomed the news after General Motors announced that it was reducing production at its Oshawa facilities.

In March, the Ontario government launched a two-phase competitive procurement process to select a preferred nuclear vendor. A commercial team, led by Infrastructure Ontario, is managing the procurement process. Team members include Bruce Power, OPG, the Ministry of Energy and the Ministry of Finance. A two-member decision review board will review the competitive process, which will be scrutinized by a "fairness monitor." A preferred vendor will be chosen based on the evaluation outcome and bidding process by the end of 2008.

The next phase of the nuclear procurement project, the request for proposals (RFP), will focus on cost of power, on-time delivery and investment in Ontario. Atomic Energy of Canada Ltd (AECL), Areva and Westinghouse have been invited to participate. They will be evaluated in three key areas: lifetime cost of power; ability to bring the new plant into operation by 2018; and the level of investment in Ontario. GE-Hitachi had also been invited to participate in the initial phase of the process but withdrew.

In the initial phase of the procurement process, the prospective bidders had to demonstrate the capability to execute a plan to provide the support necessary for a successful construction licence review and demonstrate a plan to deliver a construction licence application on schedule and in compliance with Canadian regulatory requirements.

The provincial government has reaffirmed the importance of the Bruce plant to Ontario's overall electricity plan. It said that Bruce will continue to supply some 6300 MWe of baseload electricity through either the refurbishment of the Bruce B units (Bruce units 5 to 8) or the construction of new units at the proposed Bruce C. A joint evaluation will be undertaken to assess the best option.

Annual OECD / IAEA uranium report issued

Uranium 2007: Resources, Production and Demand, the annual assessment of uranium resources was issued in late May.

It concludes that there is enough uranium known to exist to fuel the world's fleet of nuclear reactors at current consumption rates for at least a century.

The report, also known as the **Red Book**, estimates the identified amount of conventional uranium resources which can be mined for less than USD 130/kg* to be about 5.5 million tonnes, up from the 4.7 million tonnes reported in 2005. (**On 26 May 2008, the spot price for uranium was USD 156/kg).*

Undiscovered resources, i.e. uranium deposits that can be expected to be found based on the geological characteristics of already discovered resources, have also risen to 10.5 million tonnes. This is an increase of 0.5 million tonnes compared to the previous edition of the report. The increases are due to both new discoveries and re-evaluations of known resources, encouraged by higher prices.

At the end of 2006, world uranium production (39 603 tonnes) provided about 60% of world reactor requirements (66 500 tonnes) for the 435 commercial nuclear reactors in operation. The gap between production and requirements was made up by secondary sources drawn from government and commercial inventories (such as the dismantling of over 12 000 nuclear warheads and the re-enrichment of uranium tails).

The report is jointly prepared by the OECD Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA). It is based on official information from 40 countries and one country report prepared by the IAEA Secretariat. The 2007 edition includes statistics on uranium resources, exploration, production and demand as well as projected requirements up to 2030.

Bruce Power Launches Saskatchewan 2020 Initiative

On June 17, 2008, Duncan Hawthorne, President and CEO of Bruce Power, joined by Lyle Stewart, Saskatchewan Minister of Enterprise and Innovation, and Ken Cheveldayoff, Minister of Crown Corporations, announced a new program called "The Saskatchewan 2020 Initiative".

The program is intended to give provincial leaders detailed information and options as they consider their electricity supply needs for the next generation. Bruce Power plans to liaise with SaskPower to evaluate electricity demand projections for the province and examine what transmission upgrades or enhancements would be required to accommodate new nuclear units.

As part of its Saskatchewan 2020 program, Bruce Power will consider:

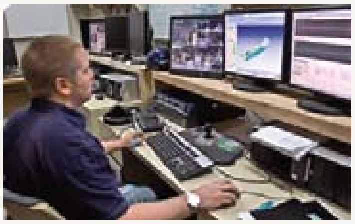
- How best to integrate nuclear energy, which produces no greenhouse gases when it produces electricity, with hydrogen, wind, solar and clean coal technologies to give Saskatchewan a diverse and secure supply of clean energy for 2020 and beyond.
- The economic impacts, public attitudes and level of support for adding nuclear energy to the province's current electricity supply mix.
- Potential locations that would be suitable to host a new generating station and the provincial transmission requirements needed for new nuclear and other clean energy sources.

Bruce Power intends to begin its analysis this summer and issue a report by the end of the year.

The Saskatchewan 2020 program aligns with work Bruce Power is already conducting in Alberta and Ontario as it considers building new reactors in the Peace Country north of Edmonton and at its current Ontario location approximately 250 kilometres northwest of Toronto.

AECL in Point Lepreau Vault

A full-scale replica of the Point Lepreau reactor at AECL's Saint John facility is being used to train workers and test retube tools and processes in preparation for the reactor refurbishment.



A communications control room, similar to this AECL mockup room, will be located outside the Point Lepreau reactor vault and will be used to manage and monitor vault activity during the refurbishment.

On May 30, 2008 New Brunswick Power turned over the fuelling machine vaults of its Point Lepreau reactor to Atomic Energy of Canada Limited to allow AECL to begin the retubing of the reactor

AECL, as project manager, now has lead management responsibility for all activities involving the retube and refurbishment of the reactor, including construction, scheduling, outage management, safety and radiation protection.

This major milestone represents the culmination of significant joint planning to prepare the Point Lepreau facility for the removal and replacement of 380 fuel channels and associated feeders (retubing) and refurbishing and upgrading other key components and systems.

Since the shutdown of the Point Lepreau reactor in late March, New Brunswick Power has accomplished many technical and industry firsts. This included the first successful de-fuelling and draining of a CANDU 6® reactor. This was completed with the help of AECL's Fuel Handing Services group, which redesigned and supplied the de-fuelling hardware.

The reactor vault is currently being vacuum dried in preparation for the first step – the removal of the feeder tubes. Preparation for the reactor's life extension has been a huge undertaking – AECL has developed more than 50 highly automated systems for fuel channel and calandria tube replacement. Many of the tools are first-of-a-kind, while others are based on tools used for reactor construction.

Calandria tubes being removed from Bruce 2

After overcoming challenges to adapt tools and equipment to the condition of the 31-year-old reactor, on June 5, AECL's retube team removed the first of 480 calandria tubes from the Bruce Unit 2 reactor.

During early attempts, the tubes proved too slippery for the tools when gripper claws inserted inside the components did not hold.

Attributed to tube hardening brought on by years of irradiation, oxide buildup on the inside the tubes and the design of the claws themselves, the problem was solved by modifying the grippers with additional carbide tips, enlarging the contact surface between the grippers and the tube, and adjusting the tool settings with updated software.

The retube team had removed the pressure tubes between December 14 and March 12.

Radioactive from the 18 years the reactor was in service, the tubes are removed with a series of remote controlled tools. To reduce radiation exposure, operators work outside the reactor vault in a Retube Control Centre using video surveillance and computers to manipulate the tools.

The process is simple but it takes a complex series of automated tools working in synchronization to make it happen. A tool on the west face of the reactor pushes the horizontal tubes, one at a time, through the calandria, while a tool on the east face pulls at the same time. Guided into transfer cans, which serve as a contamination barrier, the six-metre-long tubes are then picked up by a crane-like Remote Tool Carrier (RTC) and swung perpendicular to the reactor onto a narrow pallet.

The tubes are fed, about half a meter at a time, from the transfer can into a volume reduction press. Cutters arranged in angles then crush and shear the tubes into small pieces, about five centimeters square. The squares are ejected into a Retube Waste Container (RWC) positioned below.

When the waste container is full, tool operations cease and the RWC is rolled out from under the press. The RTC places a lid on the container and then crews use a tow motor to transport it to the Construction Retube Building. The lid is welded into place and the RWC is shipped to the refurbishment waste building at the Western Waste Management Facility.

In Unit 1, the retube team continues to the remove the reactor's 960 end fittings.

Safety record for Bruce restart project

In mid June Bruce Power reported that the Bruce A Restart Project had surpassed 10 million hours without an acute lost-time injury.

Bruce A vice-president John Sauger commented that in his broad experience he could not recall any project of comparable size achieving such a record.

Launched in the fall of 2005, the project to restart Bruce A Units 1 and 2 boasts a workforce of more than 2,200 people who are safely performing more than 145,000 activities, including high hazard, first-of-a-kind work such as replacing 16 gigantic steam generators and all of the reactors' internal components.

Peter Bailey, the project sponsor for AMEC, which provides project management expertise and support for the restart, commented that reaching the 10-million-hour safety threshold is a testament to the combined efforts of all members working toward the common goal of safety first.

Other major contractors involved in the restart include Acres-Sargent-Lundy-Fox, Atomic Energy of Canada Limited, Babcock and Wilcox, Comstock, Crossby Dewar, E.S. Fox, RCM-Fox, SNC-Lavalin Nuclear, SNL-Aecon and Siemens.

Work is currently under way to restore the structural, mechanical and electrical systems around the 16 new steam generators. Work to disassemble the reactors continues in both units, as does work to overhaul their turbine generators.

Unit 2 is scheduled to return to service in 2009, followed by Unit 1 in 2010.

Durham Region conducts nuclear emergency exercise

Coordinated by its Emergency Management Office officials of Durham Region (where the Pickering nuclear plant is situated) and associated organizations conducted a "nuclear emergency" exercise on June 12.

About 200 people from 20 organizations were involved, including police, fire, utility, transit and public works. A coordinating centre was set up in the Iroquois Park Sports Centre in Whitby, which has be designated as the command centre if a real emergency occurred.

The scenario was an emergency at the Pickering station. Durham emergency Management Office director, Ivan Cinciura, reported that he was very satisfied with the results of the exercise.

US DoE gives $18 M for GNEP studies

The US Department of Energy has allocated $18.3 million for more detailed studies towards the advanced nuclear fuel reprocessing centres and reactors it envisages at the centre of the Global Nuclear Energy Partnership (GNEP).

The DoE is spending $5.7 million with Energy Solutions; $5.7 million with the International Nuclear Recycling Alliance, led by Areva and Mitsubishi Heavy Industries; $5.5 million with General Electric-Hitachi; and $1.3 million with General Atomics.

The latest awards follow a $16 million spend in October 2007 with the same groups on conceptual design studies, technology development roadmaps, business plans and a communication strategy to support decisions on the advanced reactor and nuclear fuel reprocessing and recycling centre proposed under GNEP.

The GNEP concept requires two main technological leaps.

An integrated used nuclear fuel reprocessing and recycling centre must be designed to take highly-radioactive used nuclear fuel as an input and transform it into three streams: fresh light-water reactor fuel containing recycled uranium and plutonium; advanced reactor fuel containing actinides currently thought of as waste; and a much-reduced volume of waste for permanent geologic disposal.

In addition, the advanced burner reactors that will use the actinide fuel must be developed from basic concepts outlined today.

Separately almost $10.5 million has been spent on siting studies for the new facilities while GNEP research is ongoing into advanced reactors.

Cameco Joins Global Laser Enrichment Venture

On June 20, 2008, Cameco Corporation announced that it had joined GE Hitachi Nuclear Energy (GEH) in GE Hitachi Global Laser Enrichment (GLE), a GEH subsidiary that is commercializing a third generation enrichment process using laser technology to enrich uranium for nuclear power plants.

Cameco's participation results in three leading companies supporting the commercialization of this laser enrichment technology. Cameco Enrichment Holdings LLC has acquired a 24% interest in GLE. GE remains the majority owner, indirectly owning 51% of GLE, while Tokyo-based Hitachi Ltd. indirectly owns 25%.

As part of the transaction, GLE and Cameco may sell their complementary uranium and enrichment services together if customers request proposals for combined uranium and enrichment services. The transaction enhances opportunities to collaborate on the front end of the nuclear fuel cycle.

The investment by Cameco, based in Saskatoon, Saskatchewan, extends the company's involvement in the front end of the nuclear fuel cycle.

"This investment further expands and integrates Cameco's interests in the nuclear fuel cycle as we pursue our objective to be a leading nuclear energy company, producing uranium fuel and generating clean electricity," said Jerry Grandey, Cameco's president and CEO. "It is fitting that three leaders in the nuclear industry support the development of the next generation of uranium enrichment technology."

GLE has exclusive rights to develop, commercialize and launch the technology on a global basis under a 2006 agreement with the original developer, the Australian company Silex Systems Ltd. A test loop facility, designed to demonstrate the commercial feasibility of the technology, is being constructed at

GEH's headquarters in Wilmington, N.C. GLE anticipates a start-up of its test loop by late 2008. GLE intends to make a final decision on the construction of a commercial facility as early as the beginning of 2009. Commercial facility licensing activities currently are underway to support a projected start-up date of 2012. The GLE commercial facility would have a target capacity of between 3.5 and 6 million separative work units (SWUs).

GEH announced on April 30 the selection of its headquarters site to host the potential full -scale GLE production facility if a decision is made to proceed with construction of the plant following the test loop phase. On May 12, the U.S. Nuclear Regulatory Commission notified GLE that the agency had approved a license amendment request to operate the test loop. Additional approvals would be required to construct and operate the commercial facility.

GEH is a global nuclear alliance created by GE and Hitachi to serve the global nuclear industry. Products are certified under ecomagination, GE's corporate-wide initiative to aggressively bring to market new technologies that will help customers meet pressing environmental challenges .

Appointments

Gary Newman, Bruce Power

On June 12, Duncan Hawthorne, President and CEO of Bruce Power announced the appointment of Gary Newman as Vice-President and Chief Engineer.

Mr. Newman joined Bruce Power in 2005. Previously he had worked at Nuclear Safety Solutions, Ontario Power generation and Litton Industries.

He has an Honours Bachelor of Science degree in mechanical engineering and a Masters Degree in Applied Science, both from the University of Waterloo.

Guimond to head CEA

Pierre Guimond has been appointed President and CEO of the Canadian Electricity Association. Since 1999 he was Director, Federal Government Liaison for Ontario Power Generation, but since 2003, was seconded to and located at the Canadian Nuclear Association in Ottawa. There he coordinated regulatory activities of the nuclear industry and guided policy development related to nuclear legislation. He often served as a spokesperson for the nuclear industry. Guimond had been with the CEA previously, from 19991 to 1999 as head of government relations and earlier with Consumer and Corporate Affairs Canada (now Industry Canada). Earlier he served as executive assistant and policy advisor to several federal ministers.

INSC seeks secretary-treasurer

The CNS is a member society of the International Nuclear Societies Council (INSC), which is an association of learned nuclear societies around the world. CNS Council names a representative to represent it on the INSC, which meets typically twice a year. Over the past several years at least one of these semi-annual meetings has been in conjunction with a national meeting of the American Nuclear Society.

The INSC is currently seeking someone to be its Secretary-Treasurer, who is one of the four –member executive. The others being: Chair; 1st Vice-Chair; 2nd Vice-Chair. Each holds office for two years. It has been traditional for executive members to progress through the four levels.

Typically, the society to which the Chair belongs provides someone to provide secretarial duties.

Any CNS member who might be interested in the position of INSC Secretary-Treasurer, should contact the current INSC Chair, Dr. Andrew Kadak (kadak@mit.edu) and current secretariat, Mike Diekman (mdiekman@ans.org) for further information. Please copy Ben Rouben (benjamin.rouben@sympatico.ca) and Fred Boyd (fboyd@sympatico.ca).

Annual General Meeting
first election in several years

Over 80 CNS members crowded into one of the meeting rooms of the Marriott Eaton Centre Hotel in downtown Toronto on June 3, 2008, for the 2008 Annual General Meeting of the Canadian Nuclear Society Inc.

This was the 11th AGM since incorporation. *(The Society was created in 1979 as the "technical society of the Canadian Nuclear Association" but became a separate legal organization in 1998.)*

For the first time in several years an election was necessary as there were 26 candidates for the 19 available elected positions on the governing CNS Council. The constitution calls for an automatic move of the 1st Vice-President to President. There were no specific candidates for the other Executive positions (2nd V.P. ; secretary; treasurer although write-in names were allowed on the ballots. Given the need for an election ballots were distributed prior to proceeding with the business of the meeting.

The gathering began about 11:30 a.m. with box lunches and beverages available. Eric Williams, 2007 – 2008 president, called the meeting to order about noon. The minutes of the 2007 AGM, which had been distributed by Secretary Prabhu Kundurpi, were accepted.

Eric Williams gave a brief report on his year in office *(see separate item)* and then called on John Luxat to present the Treasurer's Report. Although initially expecting a deficit, the very successful 2007 Annual Conference in Saint John, New Brunswick and an increased number of courses resulted in a surplus of over $100,000. John moved acceptance of his report and also the re-appointment of Timothy Wright as the Society's auditor. *(A copy of the Treasurer's Report with attached Financial Statements and Auditor's Report is being mailed with this issue of the Bulletin to all CNS members in good standing.)*

Then followed brief reports on several aspects of the Society's activities. Jeremy Whitlock thanked Council for supporting the recommendations of the Education and Communication Committee in its recommendations for scholarships and contribution towards a documentary on Ernest Rutherford who earned a Nobel Prize for his work on radioactivity at McGill a century ago. Ben Rouben reported that memberhsip continues to grow. Fred Boyd noted the appointment of Ric Fluke as the new editor of the CNS Bulletin. Program Chairman, Bill Schneider, reported on the number of courses offered and mentioned the planning of up-coming conferences.

While ballots were collected and counted Eric Williams passed the traditional gavel to incoming president Jim Harvie and Past-President Dan Meneley presented Eric with a plaque in recognition of his leadership over the past 12 months.

Jim Harvie spoke briefly about his vision for the Society over the coming year. *(See separate item.)*

With no further business identified, the new president closed the meeting at about 1:15 p.m.

Eric Williams, CNS President for 2007 – 2008 (L) passes the symbolic gavel to Jim Harvie, President for 2008 – 2009, at the Annual General Meeting in Toronto, June 3, 2008.

Past President Dan Meneley (R) presents a plaque to Eric Williams for his leadership as CNS President for 2007 – 2008, at the 2008 CNS Annual General Meeting in Toronto, June 3, 2008.

President's end-of-term comments

Following is a transcription of the comments by Eric Williams, CNS president for 2007 – 2008, given at the Annual General Meeting held Tuesday, June 3, 2008 during the 29th Annual Conference. "Transcription" because Eric hastily prepared these notes just prior to the AGM. He has been on a major 3,000 kilometre canoe adventure as part of a group commemorating the historic trip by David Thompson 200 years ago from the Alberta foothills to Thunder Bay. He broke off the trip (for which he was one of the organizers) to attend the Annual Conference then leaving early June 5 to rejoin his fellow adventurers in northern Manitoba. F.B

My activity as CNS President [for 2007 – 2008] began with attending the American Nuclear Society meeting [in Boston] immediately after the CNS Annual Conference in Saint John, New Brunswick. Over my term I enjoyed visiting CNS Branches in Alberta, Manitoba, Sheridan Park, Deep River, Ottawa, UOIT and Golden Horseshoe (Hamilton). I was honoured to represent the CNS at the 50th Anniversary ceremony for the NRU reactor in early November 2007. The isotope matter [of last December], refurbishment and proposals for new build resulted in media interest and provided opportunities for CNS [and its members] to talk to the technical issues involved.

The increase in the number of courses and conferences organized by the Society emphasized the need to review its mechanism for planning and executing these events. Murray Stewart and Bob Hemming [of our Council] responded with a well thought out and comprehensive report on how to better align the CNS to meet the challenges ahead. This includes the establishment of a full-time Executive Director. The CNS membership will be consulted early this fall [2008] before proceeding. Other organizational changes are anticipated. My thanks to Murray and Bob for their thought-provoking work.

I represent the CNS on the oversight committee for the World Nuclear University Summer Institute, to be held this summer in Ottawa. THE CNS has been a significant sponsor. I thank Jim Harvie and members of the CNS Ottawa Branch for their assistance with the local organizing committee.

I continue as Technical Chair of the Climate Change Technical Conference [being organized by the Engineering Institute of Canada) to be held in 2009. Plans are well advanced for an excellent program.

It was also a pleasure to be part of organizing committee for the CNS 2008 Annual Conference and to hold a special President's Plenary Session [on NWMO plans}.

In conclusion, it has been a very interesting year. Thanks to all members for the honour of being president for 2007 – 2008, and I look forward to continuing my involvement with the Society. Finally I wish to thank members of the 2007 – 2008 extended CNS Council and staff for their support and encouragement during by term as president.

Eric Williams

Message from the [new] President

(Following is the address by Jim Harvie after being formally inducted as the President of the Canadian Nuclear Society for 2008 – 2009 at the CNS Annual General Meeting held June 3, 2008 in Toronto>)

It is an honour to have been chosen as President of the Canadian Nuclear Society for the coming year. When I look at the list of people who have previously held this post I realize that it is a great privilege to join the ranks of such an outstanding group. I look forward to the opportunity to working with our new extended Council to make our Society even more successful.

It was wonderful to see an actual election at our Annual General Meeting to select members of our new Council. This shows an increasing interest among our members in participating more actively in the Society, as well as being an indication of the hard work of Dan Meneley in developing a slate of qualified candidates. To the successful candidates, I offer my congratulations and I look forward to working with you during the coming year. To those who were unsuccessful, thank you for agreeing to stand for Council, and I also look forward to working with you, because there are plenty of opportunities to participate in the activities of the Society without necessarily being a member of Council, and I hope that you will avail yourselves of some of these.

A year is not a long time to make a big impact on an organization, and as Eric has told me, it will go in very quickly. Our major task will be to continue to do the things at which the CNS has been successful in the past, and to try to do them even better. The successful courses, conferences, educational initiatives, and branch activities will continue to develop with the hard work that many people put into our Society.

We can of course anticipate interesting developments in the nuclear industry during the coming year. Decisions about new reactors in Ontario will undoubtedly be extremely important to the future of the industry. Similarly, developments in Alberta regarding the use of nuclear power for extraction of oil from the tar sands could have an exciting effect. On the regulatory side, the upbeat speech at our Annual Conference by Dr. Michael Binder, the new President of the Canadian Nuclear Safety Commission, suggests a new wind of change and hopefully will lead to a regulatory environment which continues to make safety the first priority but also aims to be fair, efficient, and to avoid being a bottleneck in the development of advances in the industry.

Our membership has been steadily increasing for several years, and this trend should continue. We should be looking for ways to attract more young people into the Society, and to get them more involved in our activities. We should also be trying to develop activities across a broader range of areas in the nuclear industry, and to make our Society attractive to people in those parts of the industry that have traditionally not been active in it. For example, while our successful maintenance and steam generator conferences attract many participants from operational areas, branch activities at several of the operating sites are somewhat limited. Similarly, our activities tend to appeal to those in the nuclear power field more than to those in radioisotopes and other areas of the nuclear industry. I would welcome any suggestions as to what we should be doing differently to try to broaden the appeal of our Society.

I would also like to find ways to encourage the members of our Society at the Branch level to participate more in our activities without necessarily having to travel to Toronto to do so. If we could succeed in this we may be able to attract people to the Society who are too busy, or not sufficiently interested, to attend Branch meetings involving guest speakers. Again, I would welcome your input.

I have been pleased to see the efforts of our Education and Communications people in supporting the Calgary Branch in disseminating accurate information in the developing debate about nuclear matters in that Province. I would like to see the Canadian Nuclear Society regarded as a respected source of accurate information about nuclear issues which the media and interested citizens would look to for factual knowledge about our field. In order to achieve this, I believe that we must avoid adopting a promotional approach (which should be left to the Canadian Nuclear Association and the Organization of CANDU Industries) and restrict ourselves to offering factual, verifiable information. In situations where the performance of the industry is less than desirable, which unfortunately has been the case in some of the recent developments, we should acknowledge the shortcomings rather than trying to downplay them, as this is necessary to developing the credibility that I would like us to achieve.

I have no illusions that becoming President of the Society has made what I have to say any more profound than before. However, I recognize that the position of the President of the CNS can carry weight in some fora where nuclear matters are debated. If our colleagues in Alberta or elsewhere consider that my participation would be helpful, I will be happy to cooperate in whatever activities are considered appropriate. Similarly, I will do my best to respond positively to any requests for presentations at meetings of our Branches.

A major activity in the upcoming year will be the implementation of recommendations of the Governance/Organization Task Force Report prepared by Murray Stewart and Bob Hemmings. As our Society grows, and the conferences and courses we organize become larger and more frequent, it is becoming more difficult to rely on volunteer members and others to put in all the effort that is required to make these events successful. The Task Force has recommended, inter alia, the creation of an Executive Director, and the utilization of Professional Conference Organizers, as a means of reducing this dependence and increasing the number of events that we are able to manage. Your Council will be concentrating considerable effort over the coming months on the implementation of the accepted recommendations, and we will be consulting with the membership at large on any matters that are likely to have a major impact on the direction the Society is headed.

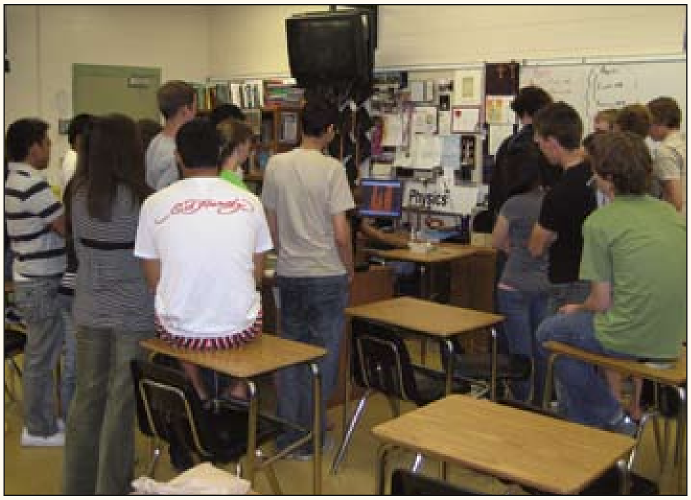
The year ahead promises to be an exciting time for the nuclear industry and for the Canadian Nuclear Society. I look forward to working with all of our members to make it a success.

Jim Harvie

News from the Education and Communication Committee – Bryan White

The ECC initiative to place Geiger detector systems in the hands of high school teachers has seen two more delivered. Mark McIntyre of the New Brunswick Branch presented one to Heather Lange of Fredericton High School, and Paul Hinman of the Alberta Branch presented one to Cliff Sosnowski of St. Laurent High School in Edmonton.

Mr. Sosnowski's students are shown enjoying the detection of potassium-40.



Branch News

Following are selected items from the reports on Branch activities over the past three months.

Alberta, *Duane Pendergast*

Duane Bratt made a presentation on "Nuclear Power in Alberta" to the Macphail School of Energy (Southern Alberta Institute of Technology), Professional Development Seminar. Calgary, Alberta (May 8, 2008).

Duane Pendergast was asked to repeat his Whitecourt/Blue Ridge presentation to fellow members of the Lethbridge Probus Club on May 21. That was bone with some minor updates. Probus members, mostly retired business people and professionals, seemed much more positive re nuclear energy than members of the Tipping Point Project in Whitecourt and Blue Ridge.

(The members of the still relatively small, but growing, Alberta Branch continue to be very active participating in many public meetings as the possibility of nuclear plants in that province increases.)

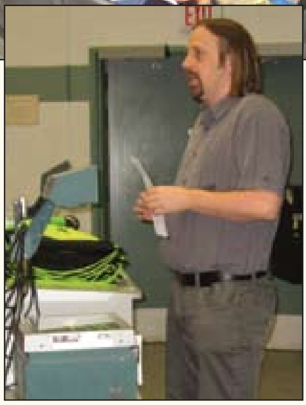
Chalk River, *Blair Bromley*

Two seminars were held in May. On May 12, John Kinney of the Toronto office of the International Atomic Energy Agency gave a presentation on international safeguards and non-proliferation. Stephen Yu of AECL Sheridan Park spoke on May 21 about the status of the ACR 1000 design.

The Branch participated in the Petawawa Science Fair in April with display and offered two prizes for projects related to nuclear science and technology.

A long-time active member, Alan Lane, died in April.

Golden Horseshoe, *David Novog*



On Saturday March 5th, the Canadian Nuclear Society co-sponsored an "Engineering Girl Guides Day" at McMaster University. Over 100 young women participated in the event and gained two badges, one in physics and the other in chemistry. For these badges the students had to complete 1 experiment in each area and then discuss the success (or reasons for non-ideal results) in small groups. It was really something to see these young and enthusiastic scientists at work. The day was a huge success and we hope to have an even larger group next year. I was proud to be a part of the event and the support of the CNS was greatly appreciated by the participants and the organizers.

The Branch ended the season with a guest speaker from IPNG in Grenoble, France who spoke about thorium cycles in CANDU.

Ottawa, *Mike Taylor*

The last meeting of the season was on April 30 when Laurie Swami of Ontario Power Generation spoke about environmental assessments for refurbishment and new build. Two meetings have already been arranged for the fall.

Québec, *Michel Rheaume*

Discussion s were held with students at the Institut de Génie nucléaire de la Polytechnique de Montréal about setting up a students Branch but they decided to be an active part of the Québec Branch.

Sheridan Park, *Adriaan Buijs*

During the spring the Branch participated in two regional science fairs: the Bay Area Science and Engineering Fair in Oakville and the Peel Region Science Fair in Mississauga. Prizes were awarded at each for projects related to nuclear science and technology.

Membership Note

Keep your individual CNS ID number handy. You will need it to identify yourself as a CNS member when registering for a CNS Conference or Course, to receive the member rate! Your ID number is shown on your annual CNS membership card. You may like to keep this in your wallet. The CNS ID number is now also shown on certificates to new members.

Also, consider the convenience of automatic renewal. The CNS Office can renew your membership each year in good time, so you will never miss the discounted earlybird renewal rate! If you are interested, please get in touch with the CNS office at 416-977-7620 or cns-snc@on.aibn.com.

Ben Rouben
Chair, Membership Committee

Note d'adhésion

Veuillez garder votre numéro de membre à portée de la main. Vous en aurez besoin pour vous identifier en tant que membre quand vous vous inscrirez à une conférence ou à un cours de la SNC ! Votre numéro de membre de la SNC apparaît sur votre carte annuelle de membre. Ce serait peut-être un bonne idée de garder la carte dans votre portefeuille. Le numéro de membre apparaît maintenant aussi sur les certificats des nouveaux membres.

Veuillez aussi noter que le renouvellement automatique est très commode. Le bureau de la SNC peut renouveler automatiquement votre adhésion chaque année, et vous profiterez aisni toujours des prix réduits de renouvellement ! Si ça vous intéresse, veuillez contacter le bureau de la SNC à 416-977-7620 ou à cns-snc@on.aibn.com.

Ben Rouben
président du comité d'adhésion

Canadian Nuclear Society
Société Nucléaire Canadienne

10th International Conference on CANDU Fuel

Delta Ottawa Hotel and Suites,
Ottawa, Ontario
2008 October 5-8

leading the Renaissance

CALL FOR PAPERS

The Canadian Nuclear Society (CNS) cordially invites you to submit a paper for the tenth International Conference on CANDU Fuel, to be held at the Delta Ottawa Hotel and Suites, **Ottawa, Ontario, 2008 October 5-8**. Canada's capital shall play host to this premier event for CANDU Fuel. This conference provides the best forum for CANDU Fuel experts from around the world to share experience, present innovations, discuss research, renew old acquaintances and network with their peers.

We Invite Papers Relating to all Aspects of CANDU Fuel Including the Following Topics

Fuel Performance: Station experience, post-irradiation examination (PIE) studies/techniques, fuel behaviour (normal operating conditions and extended burnup);
Fuel Safety: Licensing issues, accident analysis, fission-gas release, fuel behaviour and experimental simulation;
Design and Development of Fuel and Fuel Cycles: Modifications to designs, quality assurance in fuel design and development, MOX, slightly enriched uranium, recovered uranium, Thoria cycles, CANFLEX™, low-void reactivity, environmental, economical and societal implications of fuel cycles;
Fuel Model Development**:** Predictive capability on thermal, mechanical, irradiation and fission-gas-release behaviour under either normal operating or accident conditions;
Manufacturing & Quality Assurance: Fuel manufacturing experience, advances in manufacturing & inspection technologies and quality assurance;
Fuel Management: Fuel management schemes, fuel physics analysis and operational problems;
Fuel Bundle Thermalhydraulics: CHF and CCP assessments, reactor aging, crept pressure tube and fuel simulations;
Spent Fuel Management: Handling technology, spent fuel storage and disposal approaches, in-storage fuel behaviour;
History of CANDU Fuel: Developments of CANDU fuel from design, testing and manufacture viewpoints, implementation of manufacturing quality assurance standards, development of fabrication technologies for CANDU fuel, and development of computer codes demonstrating fuel performance.
Human Factor Engineering, Criticality Safety and other safety, work place and environment related papers.

Abstract & Paper Submission

Interested authors should submit a <300-word summary/abstracts indicating the planned content for the session chosen from the above list. The extended deadline for summary/abstract submission is **July 14th, 2008.** Authors will be notified of the acceptance of their submissions by **July 23rd, 2008**. Final copies of the papers must be received by **September 1st, 2008**. All accepted papers will be issued as part of the Conference Proceedings. Summaries/abstracts should be submitted in electronic form via the link given at the *Conference Papers* section of the Conference web page (accessed via the CNS web site – http://www.cns-snc.ca/fuel2008.html), or to fuel2008@cns-snc.ca, or in hard-copy to:

Holly Hamilton (stn. 63)
Chalk River Laboratories
Chalk River, Ontario
Canada
K0J 1J0
Tel: (613) 584-3311, ext. 6049; Fax: (613) 584-8214

Canadian Nuclear Society
23rd Nuclear Simulation Symposium
"The Next Generation of Simulation Tools"

2008 November 2-4
Ottawa, Ontario, Canada

Call for Papers

The Canadian Nuclear Society is organizing its 23rd Nuclear Simulation Symposium in Ottawa, Ontario, Canada, 2008 November 2-4.

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

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

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

Deadlines

- Receipt of full papers: 2008 Aug 14 EXTENDED
- Notification of acceptance: 2008 Aug 14
- Receipt of revised full papers: 2008 Sept. 15

Guidelines for Papers

Although no limit will be applied, a length of approximately 10 pages is suggested for a typical paper. Papers should present facts that are new and significant or represent a state-of-the-art review. Proper references should be included for all closely related published information.

NOTE
For a paper to appear in the Symposium Proceedings, at least one of the authors must register for the by the deadline for receipt of revised full papers (2008 September 15)

Submission Procedure

Submissions should be made electronically, preferably in MS Word format, through the Conference web page at:

http://www.cns-snc.ca/simulation2008.html

Technical Program Co-Chairs

Dr. Guy Marleau
Institut de Génie Nucléaire
Ecole Polytechnique de Montréal
e-mail: guy.marleau@polymtl.ca
Tel: (514)340-4711 ext. 4204

Dr. Eleodor Nichita
School of Energy Systems and Nuclear Science
University of Ontario Institute of Technology
e-mail: eleodor.nichita@uoit.ca
Tel: (905)721-8668 ext. 2968

General questions regarding the Conference

Denise Rouben, CNS Office Manager
e-mail: cns-snc@on.aibn.com
Tel.: 416-977-7620

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CALENDAR

2008

July 21 - 23 — **EPRI 27th Steam Generator NDE Workshop**
Palm Desert, California
email: blancaster@epri.com

Sept. 3 - 5 — **CNS CANDU Reactor Safety Course**
Toronto, Ontario
website: www.cns-snc.ca

Sept. 7 - 11 — **PSA 2008 – International Topical Meeting on Probabilistic Safety Assessment and Analysis**
Knoxville, Tennessee
contact: George Flanagan
email: flanagangf@ornl.gov

Sept. 14 - 19 — **Physor 2008**
Interlaken, Switzerland
website: www.physor2008.ch

Sept. 20 - 26 — **IYNC 2008 – International Youth Nuclear Congress**
Interlaken, Switzerland
website: www.iync.org

Sept. 30 - Oct. 4 — **NURETH 12 – International Topical Meeting on Nuclear Reactor Thermal Hydraulics**
Pittsburgh, Pennsylvania
website: www.nureth12.org

Oct. 5 - 9 — **NUTHOS-7 7th International Meeting on Nuclear Reactor Thermal Hydraulics, Operation and Safety**
Seoul, Korea
website: www.nuthos-7.org

Oct. 5 - 8 — **10th CNS International Conference on CANDU Fuel**
Delta Hotel, Ottawa, Ontario
website: www.cns-snc.ca

Oct. 13 - 18 — **16th PBNC – 16th Pacific Basin Nuclear Conference**
Aomori, Japan
website: www.pbnc2008.org

Oct. 19 - 24 — **IRPA 12 – 12th International Congress of the International Radiation Protection Association**
Buenos Aires, Argentina
website: www.irpa12.org.ar

Nov. 2 - 4 — **CNS Symposium on Simulation Methods in Nuclear Engineering**
Marriotte Hotel, Ottawa, Ontario
website: www.cns-snc.ca

Nov. 16 - 18 — **8th CNS International Conference on CANDU Maintenance**
Metro Toronto Conference Centre and Intercontinental Hotel, Toronto, Ontario
website: www.cns-snc.ca

2009

May 12 - 15 — **EIC Climate Change Technology Conference**
McMaster University
Hamilton, Ontario
email: jacksond@mcmaster.ca

May 31 - June 2 — **30th Annual CNS Conference & 33rd CNS/CNA Student Conference**
Calgary, Alberta
website: www.cns-snc.ca

Nov. ?? — **6th CNS International Steam Generator Conference**
Toronto, Ontario
website: www.cns-snc.ca

*[**Ed. Note:** The new CNS Council and Members-at-Large for 2008-2009 was announced at the Annual General Meeting of the Canadian Nuclear Society on June 3, 2008. The members are listed below. The complete listing with subdivisions normally found on the last page of the Bulletin is being updated and will be included in the next edition.]*

CNS Council 2008-09

Executive	Affiliation	Executive Position
J. (Jim) Harvie	Retired (formerly CNSC)	President
E.L. (Eric) Williams	Retired (formerly Bruce Power)	Past President
E.M. (Dorin) Nichita	University of Ontario Institute of Technology (UOIT)	1st Vice-President and President-Elect
A. (Adriann) Buijs	AECL	2nd Vice-President
E.M. (Ed) Hinchley	Retired (formerly AECL)	Treasurer
P.S. (Prabhu) Kundurpi	Retired (formerly OPG)	Secretary
K.L. (Ken) Smith	UNECAN	Member-at-Large/Financial Administrator
B. (Ben) Rouben	Retired (formerly AECL)	Member-at-Large/Executive Administrator

Members at Large

W.G. (Bill) Schneider	Retired, (formerly Babcock & Wilcox Canada)	D. (Dave) Novog	McMaster University
B. (Blair) Bromley	AECL	J. (Jad) Popovic	ZP Techology Solutions Ltd
D. (Duane) Penderrgast	Computare	M.J. (Murray) Stewart	Executive Director, World Energy Council
P. (Parvaiz) Akhtar	Retired (formerly CNSC)	B. (Ben) Rouben	Retired (formerly AECL)
P. (Peter) Lang		P. (Pierre) Girouard	AECL
W. (Bill) Garland	UNENE	K.L. (Ken) Smith	UNECAN
F. (Frank) Doyle	Candu Owners Group	S.M.H. (Syed) Zaidi	Retired (formerly NB Power)
J. (John) Roberts	Cantech Associates Ltd.	J.J. (Jeremy) Whitlock	AECL
K. (Kris) Mohan	Consultant (formerly AECL)	M. (Mohammed) Younis	Nuclear Safety Solutions (NSS)
L. (Len) Simpson	Retired (formerly AECL)		

Survivor: Canada

by Jeremy Whitlock

The reality game has never been more exciting than this year in Canada, where tribes are voting, heads are rolling, and ratings are soaring.

The year started with the high drama of an all-out "Big Brother" squabble in the House of NRU: Operator and Regulator just couldn't see eye to eye ("I asked you not to leave your dirty underwear on the floor!" "No you didn't!" "Yes I did!"…). Meanwhile Government grew angrier with each episode, while Customer sat in the corner and tried not to get involved. Millions of viewers the world over tuned in for the thrilling climax, as Big Daddy Parliament showed up, banged both their heads together and sent Regulator to the movies to cool down.

Then, with the brashness of Sweeps Week, viewers were immediately segued to the "Apprentice" intrigue of the epilogue. Head Honcho Regulator, leaving a trail of destruction more reminiscent of "The Sorcerer's Apprentice", proceeded to declare herself a nuclear expert, re-interpret elementary safety concepts, and scare the pants off residents around Chalk River. The familiar "you're fired!" finally echoed across TV land and put an end to that silliness.

The coming of spring brought the final episode of the long-running Amazing Maple Race, and it exceeded all expectations. For years teams of physicists and engineers had chased around the clock, unearthing clues, deciphering cryptic messages, jumping from one dead end to another in a mad dash to an ever-obscured finish line. Lives changed, marriages buckled, health suffered, careers stalled. In the end the machine worked, and always did, but with a complexity that exceeded the best analytical abilities by a margin not seen since the Montreal Lab conjured NRX with slide rules and ingenuity. The difference now is a regulatory environment that demands the moon, and a designer that promises it.

The final episode brought *Deus ex Machina* upon the whole cheerless affair, lowering the curtain on innovative research reactor development that may not be currently possible in Canada.

Meanwhile in the halls of Ontario bureaucracy it's "Last Reactor Standing" as a committee decides what reactor technology to build for the people. The people, of course, already own a technology that they've been benefiting from for half a century. That technology consumes uranium with an efficiency that consumes the competition in trying to come up with bad things to say about it. It is the Arrow that flew, recognized as one of Canada's greatest engineering achievements, and hopefully the paper shufflers in Toronto know they hold a rocket launcher that can bring the whole enterprise down.

"Deal or No Deal" continues to draw high ratings in Alberta, and now Saskatchewan, where a mother lode of uranium under one province may be just what's needed to extract a mother lode of oil under the other. Communities and politicians in both provinces are waving the nuclear flag, and the boardrooms atop Calgary's towers have echoed the word "calandria" on more than one occasion. Where, how, and when energy flows under the big prairie sky is a difficult suitcase to pick: electricity growth alone is now outstripping its infrastructure, and that's before any serious weaning off fossil fuels has begun in the oil sands.

Finally, sneak previews of next season's big hit, "Who Wants to Buy a Crown Corporation?" are attracting attention in all quarters. A spin-off of one of Canada's longest running franchises, "How Do You Solve a Problem Like AECL?", the new series promises twists and turns that may make CBC's squandering of the Hockey Night in Canada theme song look like a Sunday picnic.

As bad as it is for ulcers and blood pressure, the new reality craze has its upside: traditional anti-nuclear challengers with their 20th-century set-piece tactics are about as disenfranchised as snowshoe salesmen on Yonge Street. They can still forge beachheads in virgin territory like Alberta, and they'll still reap handsome profits in the parade of Environmental Assessments to come, but the new reality is about using facts to find solutions, not the other way around.

If their politics are passé, however, that's not to say that politics in general don't continue to rule on every channel. Reality entertainment has never put a scriptwriter out of work.

Stay tuned.