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DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

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Cover Photo

The cover photograph shows the top deck of the NRU reactor which celebrated its 45th anniversary of going into service on May 23.

(Photo courtesy of Atomic Energy of Canada Limited)

Canadian Nuclear Society bulletin

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CNS provides Canadians interested in nuclear energy with a forum for technical discussion. For membership information, contact the CNS office, a member of the Council, or local branch executive. Membership fee is \$65.00 annually, \$40.00 to retirees, free for students.

La SNC procure aux Canadiens intéressés à l'énergie nucléaire un forum où ilf peuvent participer à des discussions de nature technique. Pour tous renseignements concerant les inscriptions, veuillez bein entrer en contact avec le bureau de la SNC, les membres du Counseil ou les responsables locaux. La cotisation annuelle est de 65.00\$, 40.00\$ pour les retaités, et san frais pour les étudiants.

Editor / Rédacteur

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A Time of Anticipation

This is being written on the Victoria long weekend, the traditional Canadian beginning of summer, when we look forward with anticipation to better days.

In the Canadian nuclear program it is also a time of anticipation. Units 3 and 4 of the Bruce A station are scheduled to restart and the latest reports are that the program is on track. Also, the first of the four units of the Pickering A station, which have been down since 1997, is expected to restart. The timing of the Pickering units is more uncertain given the many problems and delays in the restart program but various reports suggest that the end (restart) is now actually in sight. We hope that is so. If nuclear power is to regain the confidence of the Canadian public, with the possibility of new plants, it is essential that our existing plants all operate, and operate well.

The last anticipation is for the start-up of the MAPLE reactors at Chalk River. These units are critically needed if Canada is to retain its place as the major supplier in the world of radioisotopes for medical purposes. The

two MAPLE units, and the associated processing plant, are now more than three years behind schedule, a delay that has put inordinate pressure on the operators of the 45 year-old NRU reactor, which continues to be the sole source of medical isotopes. They have continued to do a remarkable job.

Officials of Atomic Energy of Canada Limited have testified at recent hearings of the Canadian Nuclear Safety Commission that the MAPLE reactors are ready to be raised to full power, despite continuing problems. However, at the time of writing, the regulator has not yet authorized such operation. Further, there are reports that the associated processing facility is even more behind schedule.

Let us hope that as the warm days of summer bring new life to the world around us that they also herald a new beginning to our nuclear program.

Fred Boyd

IN THIS ISSUE

This issue of the CNS Bulletin has two main themes.

But, before presenting those there are two good letters we invite you to read and let us know if you agree or not with the authors.

The major topic is the **Nuclear Industry Seminar** (formerly known as the Winter Seminar) of the Canadian Nuclear Association. Held in mid March this year's event drew the largest attendance in the history of these seminars and presented papers, comments and views by many of the leaders of the Canadian nuclear program.

There is an overview report, along with the remarks of Minister of Natural Resources Herb Dhaliwal in **Minister's Address**, the views of CNSC president Linda Keen in **Regulator's Perspective**, and the text of the theme address by Geoffrey Ballard entitled **Nuclear Power and the Hydrogen Economy**.

Accompanying the address by Linda Keen there is an account of an interview with her in **Conversation with Linda Keen.**

The other major topic is **Nuclear Education** which begins with a short summary under that title followed by a note on the now functioning Universities Network of Excellence in Nuclear Engineering, **UNENE**, a descrip-

tion of the new **University of Ontario Institute of Technology** and a report on the **CANTEACH** program to collect and make available design information related to CANDU reactors.

To respond to occasional criticism that we are too parochial there is a paper with the enigmatic title **Mother Mk II**, a description of an advanced gas (helium) cooled reactor concept.

Then, as one more contribution to our continuing historical series we reprint the paper presented by Lorne McConnell at last year's Annual Conference on **NPD**.

There is the typical eclectic selection of items in **General News** and, of course, news of our Society in **CNS News**. There you will find last minute information on this year's Annual Conference, including a registration form.

The calendar is updated and some recent publications of possible interest are listed. And, last but certainly not least, there are the closing words of Jeremy Whitlock in **Endpoint.**

Your comments, suggestions and even criticism are always appreciated.

LETTERS

Need Open Discussion of Problems

The editorial in the February edition of the CNS Bulletin (A Mixed Record) offers some interesting comment on both positive and negative aspects of the recent history of the nuclear industry in Canada. Positive news was the success of overseas projects in Korea and China, while the other side of the ledger includes the embarrassment of bringing in American experts to run Ontario's reactors and the delays in completing the Maple reactors and in restarting the Pickering-A units.

What is somewhat disturbing is the fact that the editor felt it necessary to precede the editorial with a disclaimer, almost amounting to an apology for daring to mention these negative aspects. Equally, the papers presented at the recent annual seminar of the Canadian Nuclear Association avoided any serious discussion of problems, and generally presented nothing but a rosy picture. It appears that the nuclear industry has become so obsessed with political correctness that it is very difficult for knowledgeable people to discuss anything that has not gone well or the lessons that might be learned from these experiences.

Those of us who believe that significant development of new nuclear power projects is essential to long-term security of energy supply (not to mention Canada's Kyoto commitments) are frequently faced with arguments about the well-publicized failings of the nuclear industry. Questions arise as to why the Canadian public should invest more money in an industry that was so badly managed that it was necessary to bring in Americans to run it (in Ontario). and that, despite the hundreds of millions of dollars spent on refurbishment, has failed to restart even one of the Pickering-A units on anything like a schedule, let alone all four. Similarly, those who would support the revival of a Canadian Neutron Facility are questioned as to why investment in such a project is justified given the industry's failure to construct a relatively simple reactor such as Maple without serious design and manufacturing problems.

The political correctness of the Canadian nuclear industry makes it difficult to refute such arguments. We cannot explain why building Advanced CANDU Reactors would not face the same cost and schedule overruns as the refurbishment of Pickering-A, because there is no discussion of the reasons for the Pickering-A situation. We cannot give assurance that such reactors would not face the same problems that resulted in the need for American expertise and early closure of reactors because there has been little meaningful discussion of the underlying causes of these unfortunate experiences. Without such assurances, it will be difficult

to muster the public and political support that is needed for any serious progress in further nuclear developments in Canada.

It would be useful to have someone involved in the Pickering-A restart, or the Maple project, to write an article or present a paper discussing the problems that have been encountered and what can be learned from them. This might help to avoid such difficulties in future projects, and enable us to refute arguments that these problems justify abandoning further nuclear development. Unfortunately, given the current climate, it would be very difficult for anyone in the industry to do so.

Successful industries grow through their successes and learn from their negative experiences. I recognize that some opponents of the nuclear industry can use any frank discussion of shortcomings as ammunition, but it is unhealthy to have political correctness to the extent that it is necessary to apologize for an editorial that contains even mild criticism of the industry.

Jim Harvie.

Jim Harvie was formerly Director General of Reactor Regulation at the Canadian Nuclear Safety Commission

Protecting the Environment?

Are we really trying to protect the environment by focusing on releases of human-made radioactivity? The Canadian Nuclear Society ought to be aware that use of nuclear energy already protects the environment by reducing the burning of coal and other fossil fuels. Yet this aspect of the issue was not mentioned by any of the speakers at the December 5-6, 2002 CNS, CNA & COG seminar and workshop. (See Vol. 24, No. 1 issue of CNS Bulletin.)

Instead of asking "How to ensure protection of the environment from the effects of the release of radioactive material?" we should be asking – How to protect the environment from the activities of pseudo-environmentalists and regulators? These people create public health concerns leading to regulations that become major barriers to the implementation of nuclear power projects. Costs increase greatly and become unpredictable, making nuclear projects uneconomic. The negative images make them undesirable. As

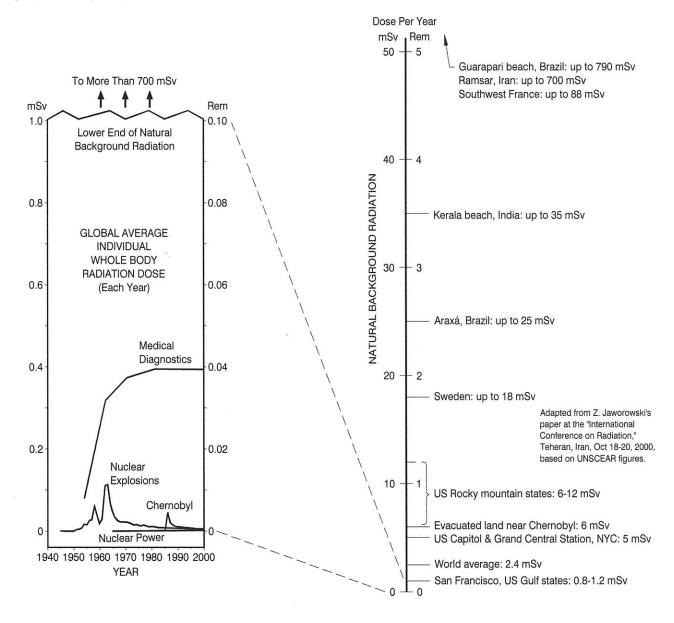
a consequence, fossil fuel combustion is employed instead of nuclear fission to supply increasing energy needs or to replace the energy from nuclear plants that were cancelled or shut down. The impact of these concerns about radioactive releases on the refurbishment of old plants and the possible construction of new plants should be very alarming to the CNS, CNA and COG, yet these organizations seem to be endorsing what is happening!

Figure 1^[1] is based on UNSCEAR 2000 data,^[2] and it demonstrates that nuclear power plants cause a relatively insignificant radiation exposure compared with exposures from natural radioactivity in the environment. During a recent visit to the Radiation Biology Department at Chalk River Laboratories, I learned that caribou and elk in the Arctic receive an average annual dose of approximately one Gray (100 rad), just from the polonium-210 in the lichen

that they eat. We could examine also the dose from the radon that the many burrowing animals inhale. So I asked, in the seminar, whether we will consider evacuating all living organisms from areas of high natural background radiation. (The question was ignored.) It seems we will create new regulations to protect non-human biota from relatively insignificant amounts of human-made radiation without regard for the much greater amount of natural radiation they receive. It is truly difficult to understand what ethical considerations are at play here.

I pointed out in the seminar that potential releases of human-made radioactivity would result in exposures in the low dose range, which are beneficial to living organisms. Why are we trying to protect them against the potential of a beneficial exposure? The response I received was that the adaptive response is not universally established – there are

Figure 1. Comparing the average annual dose: natural vs. human-made radiation, Rockwell I



uncertainties – and, in any case, we must protect radiation-sensitive and cancer-prone individuals.

I replied that there is a very large amount of scientific evidence identified over the past century that disproves the hypothesis that low doses of radiation are a significant cause of cancer and supports the contention that low doses are beneficial.^[3,4] The hormetic model is not an exception to the rule – it is the rule.^[5]

I also referred to very important scientific evidence from Chalk River Laboratories, which demonstrates convincingly that a low dose of radiation is beneficial even to radiation-sensitive and cancer-prone animals.[6] A well-known scientist in radiation biology from McMaster University rose and supported my view on this point. But the speakers showed no interest in this Canadian research.

This program to introduce new regulations to protect the environment from human-made radiation is a step in the wrong direction. It goes against the scientific evidence. It will create even more barriers against nuclear power projects at a time when energy costs are increasing. The CNS – a science-based organization – should take a stand against this anti-nuclear activity that only creates more negative images.

Jerry Cuttler

Jerry Cuttler was formerly with Atomic Energy of Canada Limited. He now has his own consulting company Cuttler & Associates Inc. He can be reached by e-mail at: < jerrycuttler@rogers.com >

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Call for Papers PBNC 14

14th Pacific Basin Nuclear Conference Honolulu, Hawaii March 21 - 25, 2004

The Pacific Basin Nuclear Conferences take place every two years. They bring together representatives of the nuclear programs in countries around the Pacific rim, the countries with the most active nuclear programs in the world.

The 14th Pacific Basin Nuclear Conference is being organized by the American Nuclear Society. It will reflect on past accomplishments and look ahead to the development of new nuclear technologies for the 21st century.

Papers are invited on a wide range of topics within the broad theme of the conference.

Abstract Deadline: August 15, 2003

Contact: Ellen Leitschuh

American Nuclear Society e-mail: eleitschuh@ans.org

web: www.ans.org/meetings/pbnc

Nuclear Industry Seminar

Annual event draws record attendance to hear wide-ranging views on the present and future of nuclear energy in Canada



Minister Herb Dhaliwal addresses reception of Nuclear Industry Seminar, March 18, 2003.



Duncan Hawthorne



Ron Osborne

The 2003 Nuclear Industry Seminar, organized by the Canadian Nuclear Association, drew a record attendance of over 300 to the Chateau Laurier in Ottawa, March 18 and 19.

As has been the pattern for the past few years the event began the first evening with a reception in the West Block of the Parliament Buildings where industry representatives mingled with a good number of politicians and senior officials while enjoying an extensive offering of food and beverages.

The highlight of the evening was a short address by Herb Dhaliwal. Minister of Natural Resources Canada. He spoke about a number of developments at the federal level that affect the nuclear program, commenting on the clarification of the Nuclear Safety and Control Act to eliminate the potential liability of investors in nuclear projects and the bringing into force of the Nuclear Fuel Waste Act. He stated that the government is committed to supporting nuclear research and development, noting the "pivotal role" of Atomic Energy of Canada Limited, and stated that federal government was participating in the negotiations on the location of ITER. (A slightly edited version of Dhaliwal's address is reprinted in this issue of the CNS Bulletin.)

At the seminar proper, opening remarks were given by Allan Kupcis and Bill Clarke, chairman and president, respectively, of the CNA, and Ian Wilson, president of the Canadian Nuclear Society, which co-hosted the event. The seminar began with a panel on the topic "Nuclear Power Generation in Canada: A View to the Future" with

concise presentations by: **Duncan Hawthorne**, CEO of Bruce Power; **Ron Osborne**, president of Ontario Power Generation; **Stewart MacPherson**, president of New Brunswick Power; and **Robert Van Adel**, president of AECL. The three utility executives each took a slightly different approach to their assigned topic.

Duncan Hawthorne spoke of the need for a diverse mix of energy supply and noted developments in other countries. "If Canada is to achieve its goal of reducing greenhouse gas production by 240 megatonnes over the next decade, people need to know that nuclear power is the only large-scale generation option that does not emit greenhouse gases", he stated. He was critical of action of the Ontario government to cap the price of electricity price, saying, " The current retail price cap in Ontario...artificially shields [consumers] from the true market price. As a result, consumers are undesirably stimulating electricity demand and further worsening our demand-supply imbalance.". He commented that although returning Bruce A units 1 and 2 to service is a "viable option" they will not pursue it under the current situation.

Ron Osborne primarily spoke of the situation at OPG and provided an update on the return of the four units at the Pickering A station to service. He noted that the primary heat transport system of Unit 4 (the first to be re-started) had been pressurized the previous week and that OPG would be seeking approval from the Canadian Nuclear Safety Commission to remove the "guaranteed safety shutdown" in April. He reviewed OPG's safety and production data and the efforts of OPG to communicate with the public.

After a brief comment on the international scene **Stewart MacPherson** spoke of the many factors affecting the future of nuclear power. Some, such as external economic conditions and public policy, are outside the control of the industry. However, he said, the nuclear industry can take steps to improve public acceptance, the problem of ageing workforce and investment risks. On the last, he noted that the system of crown corporations and rate-of- return regulations is past and argued for government / industry partnerships.

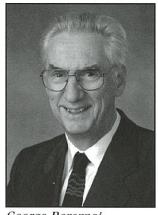
With comments that presaged the restructuring



Robert Van Adel



Geoffrey Ballard



George Bereznai

of AECL announced a couple of weeks later, Robert Van Adel began by speaking of a new approach at the company. He noted the addition of "expertise in business development, deal structuring and corporate and project finance to complement AECL's traditional strength in innovative technology". On the ACR project he said that progress in the United States had exceeded their expectations and that the ACR 700 was short-listed by three major utilities participating in the US Department of Energy's "Early Permitting " process. Van Adel also commented on a study to be released soon by the Canadian Energy Research Institute which shows that steam for the oil sands from a nuclear plant is competitive with that produced by natural gas.

Although Van Adel closed by inviting questions the tight schedule led moderator **George Anderson** to cut off the discussion period.

The remainder of the morning was devoted to three presentations on Climate Change; Nuclear Regulation and the new Nuclear Waste Management Organization.

Gerald Grandey, president of Cameco Corporation and also chairman of the World Nuclear Association spoke on "Climate Change and Nuclear Power: A World

View". He began by reminding the audience that it was 50 years ago that US President Eisenhower gave his "Atoms for Peace" address to the United Nations, which led to the creation of the International Atomic Energy Agency and the gradual declassification of most nuclear information. Noting the world's need for energy and the desire to reduce emissions he argued that nuclear combined with hydrogen was the only answer.

Next was **Linda Keen**, president of the Canadian Nuclear Safety Commission, who titled her address: "Issues Facing Nuclear Industries: The Regulator's Perspective" with several references to a joint CNSC / CNA committee, she concentrated on four issues: Smart Regulation; Cost Recovery; Safety Culture; and International Safeguards. (The text of Ms. Keen's address is printed elsewhere in this issue of the CNS Bulletin along with a report on an interview with her.)

The last speaker of the morning was Elizabeth **Dowdeswell**, president of the Nuclear Waste Management Organization, who outlined the early work and proposed program of that new agency. She began by commenting that a major challenge is attitudinal and behavioural change of both individuals and institutions. "The nuclear industry is being shaped by factors much beyond the scientific and economic", she stated, "social and ethical considerations demand their place at the table". She went on to describe the early work of the NWMO, which involved many focus groups, and other methods of gauging people's views of nuclear waste. Next the NWMO will begin to develop a framework for analysis of various approaches with further consultations with "communities of interest". Finally, within the three year limit set by the legislation, the various possible approaches will be evaluated and a report to the minister prepared.

The keynote address of the seminar was given by **Geoffrey Ballard**, founder of Ballard Power Systems and now chairman of General Hydrogen Corp., at the luncheon.

The world will need more energy as the population grows and people everywhere seek a better standard of living, Ballard asserted. The challenge is to provide this energy without further harming the environment or increasing the pollution of our cities. Transportation is key and the solution, he proposed, is the "hydricity" economy, combining nuclear power as a base energy source with hydrogen as the energy "currency" through the use of fuel cells. (*Dr. Ballard's address is reprinted in this issue of the* CNS Bulletin.)

The first panel session of the afternoon concentrated on education, moderated by **Thomas Brzustowski**, president of the Natural Science and Engineering Research Council. Speakers were: **George Bereznai**, dean of the School of Energy Engineering and Nuclear Science at the new University of Ontario Institute of Technology; **David Jackson**, professor at McMaster University and **John de la Mothe**, who holds the Chair of Innovation Strategy at the University of Ottawa.

Bereznai described the nuclear related courses to be offered at UOIT and Jackson outlined the background to the formation of the recently created Universities Network of Nuclear Engineering Excellence (UNENE). (The content of their presentations is included in the reports on "Education" in this issue of the CNS Bulletin.)

This panel was followed by a presentation on "Nuclear Energy and International Environmental Issues" by Bruno Comby, the founder and president of the Association of Environmentalists for Nuclear Energy (EFN), which is based in France.

Starting off with illustrations of the use of energy and the potential growth of demand, he emphasized the danger of continuing to rely on fossil fuels. His talk was aimed more at a general audience than one made up of representatives of the nuclear industry. For more information on EFN go to their website < www.ecolo.org >.

The final panel session, moderated by B**rian McTavish**, president of Candu Owners Group, brought together speakers on four different subjects.

Grant Malkoske, vice-president of MDS Nordion, gave one of his typically passionate addresses about the use of radioisotopes in medicine. Canada, through MDS Nordion, supplies about 2/3 of the world's medical isotopes, almost all currently being produced at the 45-year-old NRU reactor at the Chalk River Laboratories of Atomic Energy of Canada Limited. He commented that the first of the two MAPLE reactors being built by AECL for MDS Nordion was in the final commissioning phase, at 2 megawatts, and was expected to be authorized to go to full power and commercial operation within the next few months.

Michael Lees, director of Business Development and Marketing at Babcock & Wilcock Canada described how his company had managed to obtain contracts to replace reactor vessel heads of nuclear plants in the USA. B&W Canada has been successful over the past several years building replacement steam generators for US nuclear plants. Venturing into the reactor head business was a major risk but the company has now supplied several heads.

An update on the negotiations for the siting of the large ITER fusion project was provided by **Murray Stewart**, president of Iter Canada. After reminding the audience about the essence of the Iter project, he noted that the USA and China had recently joined with the European Union, Japan, the Russian Federation and Canada. There are now four sites being considered: Rokkosho in Japan, Cadarache in France and Vandellos in Spain besides the Canadian proposal of

Clarington (beside the Darlington NGS). Further site negotiation meetings were scheduled for April and May, leading to "high level political discussions" over the summer. The final decision is to be made at the time of the meeting of the General Assembly of the United Nations in September 2003. Stewart commented that Canada was in the process of modifying its bid.

The last presentation was by **John Root**, director of the Neutron Program for Materials Research. Although the program is under the National Research Council the work is physically conducted at AECL's Chalk River Laboratories, using the NRU reactor. He noted some of the special characteristics of neutron beams that permitted examination of materials impossible by other means. More information can be obtained at the website < www.neutron.nrc.gc.ca >.

Despite this long and imposing list of speakers the seminar finished close to the scheduled time of 5:00 p.m. for the closing reception.

Most of the papers are available in "PowerPoint" or "pdf" formats on the CNA's website < www.can.ca >



A view of the reception at the Nuclear Industry Seminar, March 18, 2003.

Chateau Laurier: venue of Nuclear Industry Seminar, March 2003.

Nuclear Industry Seminar

Minister's Address

Following is a slightly edited version of the remarks by the Minister of Natural Resources, Herb Dhaliwal, at the opening reception of the CNA Nuclear Industry Seminar, in Ottawa, March 18, 2003.

I am honoured to speak to you again this year and would like to commend you on organizing this forum.

I have enjoyed getting to know you and your industry better over the past year. I was delighted to visit Chalk River and MDS Nordion in Kanata. Your [CNA] TV and newspaper ads are an excellent

way to help people understand how your industry contributes to the quality of life of Canadians.

Today, I'd like to talk about developments in the federal policy agenda that are important to your industry.

First of all, climate change.

2002 was a year of reckoning for everyone when it came to climate change: for industry, for consumers and for the Government of Canada. The demand for cleaner energy is increasing, in Canada and around the world. We are starting to see some of the pressure points of our energy supply system. As you know, this winter we faced an increased demand for energy — and there have been challenges in meeting these demands.

Here in Ontario a few weeks ago, for instance, we came dangerously close to a power shortage, prompting Ontario to import extra power, and to call for consumers to conserve energy — at a time of extreme cold. Incidents like this bring into sharp focus the pressures on our energy supply.

Environmental and supply concerns have also increased the call for changes in the way we produce and consume energy.

Nuclear — as an energy source that produces no greenhouse gases — will have to play an important role in responding to this need for new and cleaner forms of energy. At the same time, we need to build on Canada's proven track record of using nuclear technology wisely.



Smart Regulation

In the last Speech from the Throne, the Government of Canada committed to smart regulation that promotes health and sustainability. That contributes to innovation and economic growth. And that reduces the administrative burden on business.

I am proud that the Canadian Nuclear Safety Commission ensures public health and safety. As a businessman, I certainly understand how important smart regulation is to your industry — to your ability to compete for investment dollars and to stay

competitive in today's market.

I am aware that there are ongoing discussions regarding proposed regulations such as the Commission's cost-recovery fees.

I believe that, for the nuclear industry to be safe and economically viable, it must have in place a stringent, efficient and cost-effective regulatory regime.

My colleague, Industry Minister Allan Rock, has ordered the time frame for a regulatory review of key sectors to be moved up to 2005. Meanwhile, we're moving ahead as quickly as we can to address long-standing challenges.

For instance, in the past year, we clarified a section of the Nuclear Safety and Control Act — Bill C-4. You can now compete for project financing on an equal footing with other sectors. I'm pleased that passage of this bill has contributed to the successful change in ownership of the Bruce Power plant to a Canadian consortium.

And we brought into force the Nuclear Fuel Waste Act. This new Act provides a framework to develop a strategy for long-term waste management. A strategy in which the public can have confidence. Under this Act, nuclear utilities have already established the Nuclear Waste Management Organization. Major owners have begun to set aside funding for waste management activities.

Social Responsibility

We must reassure Canadians that we have one of the most stringent nuclear regulatory regimes in the world, one that gives utmost priority to safety and security, public health and environmental protection. We must ensure that we are being good stewards of our environment, such as cleaning up the low-level radioactive waste in the Port Hope area. The Government of Canada is investing \$260 million over ten years to help the municipalities manage the waste over the long term.

Canadians are also concerned about social corporate responsibility — that businesses be committed to contributing to the quality of life of local people and communities through voluntary actions.

I'd like to take this opportunity to congratulate Cameco Corporation for receiving a gold award from the Canadian Council for Aboriginal Business recognizing its commitment to Aboriginal communities.

Research and Development

If nuclear is to be an energy source of choice in a carbon-reduced world, the energy you provide has to be competitive. This requires long-term strategic thinking on all of our parts, and I encourage you and your industry to maintain your efforts in this area.

I commend the CNA for its work with my department and the Innovation Secretariat on the Clean Electricity Generation Initiative.

In terms of innovation, we know that the industry is on the verge of some promising new technology developments and is working hard to ensure that they are energy technologies of choice in the future.

Ongoing research and development is essential to the continued safe and economic deployment of nuclear technologies domestically and abroad. The Government of Canada is committed to supporting nuclear research and development. In this respect, the team of scientists, engineers and technicians at Atomic Energy of Canada Limited (AECL) plays a pivotal role.

I am very optimistic about AECL's future prospects, which have improved dramatically. The Advanced CANDU Reactor — ACR — looks very promising to meet the challenges ahead, in Canada and abroad. AECL is seriously examining the role nuclear can play in other sectors of our economy, such as the oil sands sector.

The Government would like to strengthen and solidify its already sound commercial position.

I am pleased to confirm that we will be moving forward with a study to strengthen AECL's market competitiveness. This study will help us determine whether enhanced partnership opportunities between AECL and private business interests are feasible, desirable and in the best interests of AECL, the nuclear industry and all Canadians. It will consider the complete range of options, which could include privatization of commercial business as well as the status quo. This work will be done in collaboration with a range of stakeholders and is expected to be completed by the end of the year.

International

On the international scene, Canada continues to have a major presence with our uranium exports and the export of the CANDU technology abroad.

Canada's uranium mining industry continues to lead the world, providing about one-third of global production.

The growth of our nuclear industry will depend on continued access to international markets. The Government of Canada plays a major role in this area.

For instance, I'm looking forward to a business trip later this spring to China to strengthen partnerships and future opportunities for Canada's nuclear program. I am honoured to be attending a ceremony marking the completion of the first CANDU in China. This reactor was built in record time and on budget. It is a great success for China and Canada. I congratulate AECL and our nuclear industry on its world-class excellence.

I am also pleased that work to complete Romania's second CANDU reactor is going full speed ahead.

You should be very proud of these major accomplishments. It is a testimony to Canada's global leadership in nuclear engineering and large project management.

The Government of Canada is also participating in the Generation IV International Initiative — to look at nuclear energy systems for the new millennium that are safe, clean and sustainable. This group's work provides valuable guidance for international partnerships. The concepts being explored include the promising ACR.

And there is ITER — the next major step in developing fusion energy as a safe, clean and sustainable energy source. ITER is a truly international project, with China and the United States now joining Canada, the European Union, Japan and the Russian Federation. Canada is participating in the negotiations to locate this project here in Ontario.

A Nuclear Future

The Government of Canada is committed to ensuring that the nuclear industry continues to be an important part of our energy mix. I am convinced that it can play an important role in meeting the global demand for cleaner energy. It is a viable option to help Canada meet its objectives, especially for climate change and sustainable development.

By working together, we can ensure that a strong, competitive and sustainable nuclear industry is part of a strong and competitive Canada.



Nuclear Industry Seminar

Nuclear Power and the Hydrogen Economy

by Geoffrey Ballard

Ed. Note: Dr. Geoffrey Ballard, chairman of General Hydrogen and a pioneer in the development of fuel cells, gave the keynote address at the Nuclear Industry Seminar in Ottawa, March 19, 2003. Following is his message, slightly edited for this print format.

Introduction

My overall theme is, that if the Hydrogen Economy emerges in the transportation sector, as I believe it will, then nuclear power generation will have to play a paramount part in its evolution.

This concept recently received a large boost when President Bush announced \$1.2 billion for research into hydrogen fuel cell powered automobiles in his State of the Union Address.

Hydrogen is a currency of an energy system, not a source of energy. To create the currency, Hydrogen, primary power must be utilized. The most likely candidate to produce this power is nuclear.

Background

The consumption of energy in the developed world from the year 1850 to the year 2050 is shown in Fig. 1. The curves are normalized to provide for easy conception.

The first thing to notice is that we have been in a "Decreasing Carbon" consumption mode during this entire time. The developed world has moved from a coal, pure carbon mode, to a nuclear, oil, natural gas mix mode. It is predicted that the future will see even less carbon consumption, and eventually a carbon free economy when the potential for hydrogen is fully exploit Carbon manifests itself as the Green House Gas, carbon dioxide, when the carbon-based fuel is converted from chemical energy to useful heat energy.

There is a curve started at the bottom right called NEXT(S). It is important to any planning function to recognize that "NEXT(S)" will occur, even though we cannot take them into consideration now, because we do not know what they will be. But the fact that they will develop is a given. The current primary energy mix, roughly the vertical line [at year 2000], shows almost equal parts of natural gas and oil with a decreasing contribution from coal and an increasing contribution from nuclear. Oil, coal and natural gas are often lumped as the fossil fuel sources.

Alternative Energy sources show only a marginal contribution at this time. The largest single alternative energy

source is of course HYDRO. But, although Hydro supplies 60% of Canada's electrical energy needs, Hydro only supplies 6% of the world energy need, and for many reasons, Hydro is a very limited resource and cannot be extended significantly further.

"Alternative Energy Sources" implies an alternative to the current energy mix of fossil fuels and nuclear. They are sunlight (solar), wind, geothermal, tidal and ocean currents; (biomass and hydro are really solar). Deep earth mining of hydrogen and deep ocean solid methane is at this time included in Next(s) because they have not been proven out.

The most important thing to notice is that HYDROGEN has not been included. Hydrogen is a currency, not an energy source; and I will have considerable to say about this concept of currency. One of the most widely held misconceptions is that Hydrogen is an alternative energy source, and this misconception leads to a lot of bad thinking and inability to communicate clearly.

From this "Consumption Framework" I want to move to some nomenclature issues that often confuse rational discussion. To do this I need to invoke an "Architecture" for energy system and I have chosen transportation sector as an example.

Energy Systems are driven by what people want and they are named by their currencies.

In Fig. 2 I have listed some of the more important components of the energy systems. Note that the items in a column do not correspond with a component of the next column. They are listed just to assist in understanding the ingredients.

In the right hand column, marked SOURCES, are the

primary energy sources that nature provides. All of these sources are used to some extent, but the major sources are coal, oil and nuclear.

Hydrogen is a currency, not an energy source

In the left hand column are the SERVICES. "What

People Want". People's desires are what drive the systems, not the energy sources. We want transportation, potable water, health care etc.

The three columns in-between the wants and the sources are the activities of man, the Service technologies, the Currencies and the Transformer technologies.

I want to spend a few moments on currencies. They are exactly what their name implies. Just as we get paid for going to work in dollar bills, pounds or yen or, if you will, a

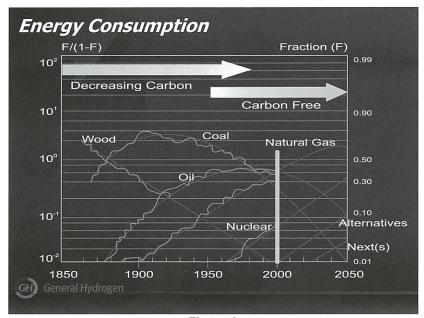


Figure I

currency, -- nature's sources of energy are transformed into currencies of gasoline, hydrogen or electricity.

These currencies are then moved to the new location where energy is need and they are there expended, in the same manner as you take your pay dollars and buy food or shelter or transportation. The currency gets the energy from source to place of need.

The next point that I want to get across is that electricity is the only common currency that has a degree of universality about it. Any form of natural energy source can be used to make electricity and the electricity can be transported to the place of need, where it can be converted into any form of energy that is required.

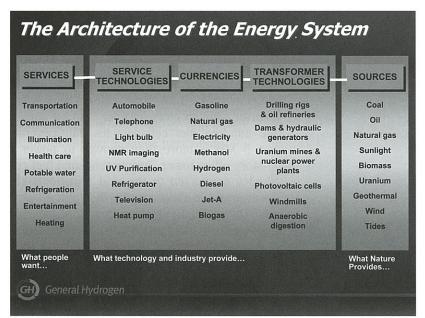


Figure 2

But electricity too has had its drawback. Until very recently, there was no economically easy way to store electricity. Hence, we had to generate the electricity that was needed at the moment. This has resulted in our electrical generation being designed for peak needs rather than for average needs, which has resulted in excessive over capacity at slack usage times.

With the advent of the **hydrogen fuel cell** much of that has changed. With a fuel cell we can now afford to generate hydrogen from electricity during off-peak times, store the hydrogen and feed it back through a fuel cell to produce electricity at peak need. The fuel cell allows us to peak shave and plan for electrical usage.

Fig. 3 compares the gasoline economy with the hydrogen economy for the transportation sector. Much of what is explained in these examples is transferable to other energy systems.

Looking first at the current in-place energy system, the gasoline economy. The first thing we notice is that the system is single source dependent. The system is dependent on reforming crude

oil into gasoline for the internal combustion engine. I will not go into the international political situations, wars and the treat of wars that have emerged from our inability to find a suitable substitute for crude oil. None of us need to be told this story again.

Now look at the same five chain link for a hydrogen economy. Any primary source of energy can be used to make electricity. Electricity can make hydrogen, which can be transported to where the energy is needed and returned to electricity. I have tried to avoid using numbers, being more interested in this discussion of dealing with concepts, but I will provide one number here.

A round trip from electricity to hydrogen to electricity is a three to one proposition. The round trip gets you back one-third of the electricity that you started with. Not a bad number when the average automobile gets only 18% of the energy in gasoline through to the rubber on the road.

The Evolution of Land Transportation is somewhat redundant, but in Fig. 4 I have tried to package a new nomenclature with some fairly new ideas.

As we look at land transportation through the ages we can clearly see the single source dependence of the current and early systems. It is also very clear that the fuel cell allows us to use any primary energy source.

In many instances one or another of the primary energy sources will dominate. In Iceland I am sure geothermal will become the eventual primary energy source. In Argentina it could well be that wind source of energy will dominate if what I hear is true concerning Argentina's intentions. Canada

If carbon based
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nuclear

will have a large component of hydroelectric for years to come and possibly will be a dominant nuclear power generator in the future. China will have to go coal for the foreseeable future and, as we know France already has 80% nuclear power generation system.

Fuel Cells

Basically a fuel cell combines air (oxygen) and hydrogen to produce electricity. There are a number

of designs currently being developed. Fig. 5 compares some of the basic factors for five designs. Fig. 6 shows the basic construction of a proton exchange membrane fuel cell and Fig. 7 illustrates how cells are combined to provide a practical package.

With the advent of an economic hydrogen fuel cell, electricity can be stored efficiently in large quantities for the first time. Prior to the hydrogen fuel cell, large amounts of electricity could not be stored economically, and electrical generating capacity had to be designed for peak loads rather than for average energy consumption.

Electricity has always been our Currency of choice. From the energy crisis of 1974 until 1990, as conservation attitudes kicked in, the per capita consumption of energy in North America leveled off. Yet during that same 16 years the per capita consumption of electricity increased by 28 percent.

Fuel Cells in Transportation

The Energy System A Five Link Chain What People Want Nature Provides Energy Energy Service Energy Transformer Currencies Services Technologies) Technologie. Sources Supply Demand - Examples -Transport Oil Refineries Crude Oil ICE Automobile Gasoline Oil, Coal, Nuclear, Wind, Solar, Fuel Cell Vehicle Transport Hydrogen Electrolysers Geothermal Ect. GH) General Hydrogen

Figure 3

The hydrogen fuel cell finally allows us to use electricity to fuel our transportation sector.

A number of recent studies in the United States and Europe start with a preamble that expresses concerns with the supply of petroleum. However, studies by the International Atomic Energy Agency [and others] show that there is at least 200 years of petroleum available even under very pessimistic circumstances. We should not, therefore, be changing the energy systems because of a fear of limited petroleum reserves.

We should change the transportation energy systems because the current gasoline system diminishes energy security, unacceptably destroys our earth's atmosphere, and sickens our children with inner city pollution. Petroleum should be focused to the petrochemical industry, not to energy supply.

The overall plan should be to move towards a hydrogen economy. To do this we must recognize that the primary energy source should be directed towards electrical production.

The excess electrical production at any moment can be converted into hydrogen.

HYDROGEN INSTEAD OF GASOLINE CAN BE THE FOCUS OF OUR LAND TRANSPORTATION NEEDS.

With this focus in mind – a nation's entire energy system can gradually shift away from dependence on oil and petroleum without a massive disruption of the economy. We can control the evolution of a nation's energy utilization into directions and systems that are appropriate for each nation and are least disruptive of our global ecology.

It must be noted, as I have stressed throughout this talk, Hydrogen is not an energy source. Hydrogen is only a currency, but it is such a currency that it makes all sources of energy available to the energy economy. It is the first truly

reversible currency.

The automobile is a natural link to distributive power. One can actually conceptualize the automobile as a stationary power plant on wheels. For example, looking first at California, there are approximately 25 million automobiles on the road today in California. If each automobile generates 50 kW, then a single vehicle can generate enough electricity for 5 to 10 homes. One hundred fuel cell vehicles can generate over 5 MW - more than enough to power a 50-story office tower. Twenty thousand fuel cell vehicles connected to the grid represents the power saved in California by the rolling blackouts. One million vehicles, or 4 % of the cars registered in California represents California's total stationary generating capacity.

It is impossible to avoid the conclusion that most of the power generating capacity of a developed nation is in its rolling motor vehicle stock. The advent of the fuel cell makes this huge power

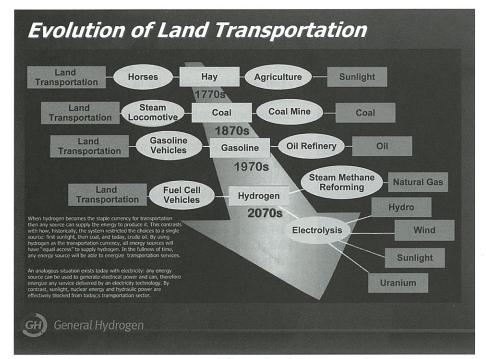


Figure 4

generating capacity available for daily use.

Broadening ones outlook from California to the developed world and then to the emerging nations, we see that only 12 % of the world population has some form of motor power transportation available to it. There are over 6 billion people in the world today with over 10 billion expected later this century. Most of these people are young, globally, aware, web-connected, and residing in emerging economies with escalating demand for personal transportation.

It is quite possible for these emerging populations to adopt the fuel cell and the hydrogen economy, and utilizing the ability offered by these technologies for distributive power, to avoid or precede the advent of a national power grid.

Understanding all aspects of hydrogen, the fuel cell, the electrolyser, takes on a new urgency. Storage, safety and education are the endeavors. Implementation strategies and their economic and social implications have become paramount.

Hydricity

As the world progresses to the hydrogen economy, I believe hydrogen and electricity will become so indistinguishable from each other that they will be referred to as a joint currency called HYDRICITY. The hydrogen economy will be realized in the transportation sector, because there it cleans up the inner-city, reduces green

house gas emissions and forms the foundation for Energy and Homeland Security. I believe that we will eventually emerge to the HYDRICITY ECONOMY.

There is much debate and worldwide concern about resurrecting the nuclear energy dream. Advocates of other systems point to wind and solar energy, but environmentally desirable as the non-carbon and non-nuclear sources of energy are, they are unlikely to provide the vast amounts of primary energy that social progress will demand, because social progress directly correlates to per capita energy consumption

If carbon based energy sources must be set aside, and I believed they must, the only remaining viable energy source, at this stage in our development, is nuclear.

\Let me put some numbers on the framework I am projecting for the transportation sector:

- If 4% of the automobiles in California were fuel cell vehicles, they would represent more generating capacity than the entire stationary generation capability of the State. Said in other words. If all the automobiles in California had 100 kW fuel cell engines they would represent 25 times the stationary generating capacity of California.
- An energy round trip of using electricity from the grid to make hydrogen and then at a later time to use a fuel cell to make electricity from the hydrogen to return to the

		PAFC	AFC	PEM	MCFC	SOFC
Temperature H ₂ /Reformate H ₂ H ₂ /Reformate H ₂ /	Electrolyte	H ₃ PO ₄	KOH/H ₂ 0	Polymer	Molten Salt	Ceramic
Reforming External External External/Internal External/Internal Oxidant O ₂ /Air O ₂ /Air CO ₂ /O ₂ /Air O ₂ /Air Efficiency 40-50% 40-50% >60% >60%		190°C	80/200°C	80°C	650°C	1000°C
Oxidant O ₂ /Air O ₂ /Air? O ₂ /Air CO ₂ ,O ₂ /Air O ₂ /Air Efficiency 40-50% 40-50% >60% >60%	Fuels	H ₂ /Reformate	H ₂	H ₂ /Reformate	H ₂ /Reformate	H ₂ /CO/Reformate
Efficiency 40-50% 40-50% 40-50% >60% >60%	Reforming	External		External	External/Internal	External/Internal
	Oxidant	O ₂ /Air	O ₂ /Air?	O ₂ /Air	CO ₂ ,O ₂ /Air	O ₂ /Air
Scale 200 kW to 10 MW 0.1 to 20 kW 0.1kW to 20MW >100MW >100MW	Efficiency	40-50%	40-50%	40-50%	>60%	>60%
	Scale	200 kW to 10 MW	0.1 to 20 kW	0.1kW to 20MW	>100MW	>100MW
Applications Small Utility Aerospace Motive/Small Utility Utility Utility	Applications	Small Utility	Aerospace	THE RESERVE AND ADDRESS OF THE PARTY OF THE	Utility	Utility

Figure 5

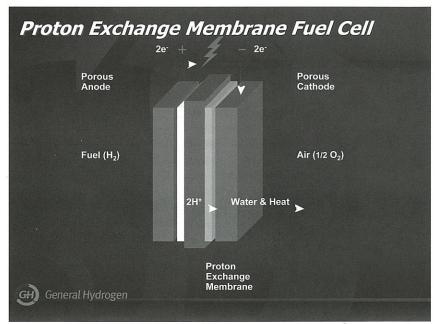


Figure 6

grid could be 35% efficient. Again, said in other words – if you bought electricity off the grid to make hydrogen for 2 cents a kWh you would have to sell the electricity you made from that hydrogen back to the grid for 6 cents a kWh, in order to break even. Not a bad trade when peak to trough energy costs in California range from 2 cents to 35 cents a kWh.

 If the hydrogen economy were in place today for onroad transportation then to provide the basic energy requirement, that replaces the current use of gasoline, would take 4,500 Gigawatts of generating capability running at 100% capacity.

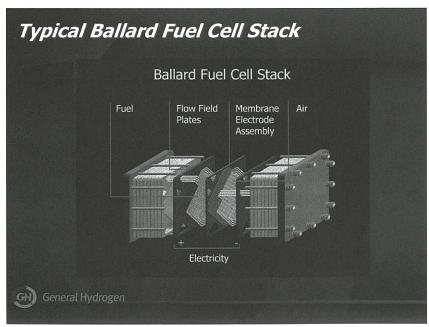


Figure 7

Two general themes have dominated my work for the last decade: cleaning up the inner-city air, and, on-road transportation vehicles as the key to our energy future.

Air pollution takes many adverse forms on earth, but the worst one to my mind is the foul atmosphere that we inflict on inhabitants of the inner city. This has been widely ignored in the environmental debates, where the arguments are directed to cleaning up the upper atmosphere, ozone holes and depletion, and warming trends that could inundate the coast.

While I agree that the data shows the earth's surface is in a warming trend from about the year 1200 to the present, I do not agree that the evidence is at all compelling that the warming trend is solely the result of man's activity. Nevertheless, cleaning up the inner city, by cleaning up transportation, has the associated effect of a major contribution to cleaning up the upper atmosphere of the greenhouse gas that has such a bad image in the public's imagination.

In closing, I think that many factors are aligning to bring about the hydrogen economy for transportation systems:

- Only 12% of the world's population has access to automobiles. When the other 88% of the world decides to drive, humans on planet earth cannot survive the pollution that will be produced from extending the current gasoline economy. I said humans will not survive. Obviously planet earth will survive, we just will not be here to enjoy it.
 - The automobile in the inner-city is already wrecking devastation on the health of its inhabitants.
 - Homeland security and energy security are greatly enhanced by a distributive source of generating capacity.
 - We have a ready-made solution to the source of primary power, nuclear energy.
 - Petroleum is a finite reserve that is better utilized in the petrochemical industry.

It will take a combined effort of Academia, Government and Industry to bring about the change from a gasoline economy to a Hydricity Economy. It is of major importance that a change of this magnitude not be forced on unwilling participants; but that all of us work for an economically viable path too change. That path, I am convinced, revolves around educating people to the use of nuclear generated electrical energy.

Nuclear Industry Seminar

The Regulator's Perspective:

- Issues Facing the Nuclear Industry

by Linda J. Keen

Ed. Note: Following is the text, slightly edited, of the presentation by Linda Keen, President and CEO of the Canadian Nuclear Safety Commission to the Nuclear Industry Seminar held in Ottawa, March 19, 2003.

Introduction

My presentation today will take a different tack compared with the presentations by the CNSC in the past few years. I will focus on a few specific and current issues that I believe require the attention of CNA members.

These issues are:

- Smart regulation;
- Cost recovery;
- · Safety culture; and,
- · International safeguards.

Smart Regulation

In the 2002 Speech from the Throne, the federal government made a commitment to smart regulation. The speech read, "The government will move forward with a smart regulation strategy to accelerate reforms in key areas to promote health and sustainability, to contribute to innovation and economic growth, and to reduce the administrative burden on business."

In the subsequent terms of reference for the advisory group, "health and safety" has replaced "health and sustainability".

While nuclear regulation was not one of the key areas specified in the smart regulation commitment, it is one of the areas where, in my view, smart regulation is already being applied.

The introduction of the *Nuclear Safety and Control Act* and the subsequent creation of the CNSC in May 2000 were early steps towards smart regulation.

On December 20 [2002] CNA President William Clarke wrote a letter to Minister Dhaliwal, copied to me, stating the view of the CNA with respect to smart regulation. This view was further clarified in meetings between the CNSC and CNA. In commenting on smart regulation, the CNA letter stated that,

"regulatory management should establish as an objective, support of innovation and research-based growth."

As the CNSC regulates for health and safety, not for economic reasons, smart regulation under the *Nuclear Safety* and *Control Act* must serve the public good and maintain

trust in the regulator.

Although the purpose of the CNSC is not to support innovation and growth, we are working to ensure that we are, to the extent possible, not standing in its way. Specific examples include:

- the proactive environmental assessment of ITER, which was an important component of the Canadian bid;
- the agreement to work on the regulatory viewpoint of the ACR 700 for AECL; and,
- the appearance of CNSC staff on behalf of Bill C-4, which removes liability for cleanup costs from creditors not in control of nuclear facilities.

I also believe that the CNSC can contribute to the sustainability of the nuclear industry by being an effective, transparent and trusted regulator whom the public can look to.

As well as being effective, we can also assist by being timely and efficient. This requires effort on both our parts to enhance the predictability of process. To do so, industry and government must provide sufficient resources for the CNSC to ensure accurate, timely responses.

The CNSC is keeping in close contact with Privy Council Office to ensure that we understand and have input into the formation of smart regulation.

The letter from the CNA President to the Minister also raised the issue of duplication of regulatory effort among different levels of government. The letter read,

"There is a critical need to avoid overlap and duplication in regulatory oversight. Not only does the nuclear industry spend significant amounts of money to deal with overlaps between federal and provincial regulators, but we see the growing emergence of overlaps within the federal government in some sectors of our industry."

Since nuclear regulation is a federal-only jurisdiction, there is, in fact, limited potential for federal/provincial duplication. However, I am pleased to announce that an Administrative Agreement with the province of Saskatchewan was recently signed in order to streamline regulation of the uranium mining industry. We have also asked the CNA, via the ongoing CNA /CNSC committee, which meets on a quarterly basis, to identify other examples of duplication where efficiencies can be found.

There are also areas where the CNSC has been proactive on its own. We are promoting greater coordination among jurisdictions in the area of emergency preparedness, and we've made progress working with provincial governments

Protection of the environment is a major responsibility of the CNSC.

to reduce duplication in the area of pressure vessel regulation.

The CNA President's letter also urged the support of innovation and research-based growth, particularly with regard to the environmental assessment and approval process. We understand that this refers to the environmental assessment process under

the Canadian Environmental Assessment Act, or CEAA.

As protection of the environment is a major responsibility of the CNSC both under the *Nuclear Safety and Control Act* and as a responsible authority under CEAA, we are working on addressing concerns, and clarifying procedures at the CNSC. CNSC staff has recently prepared a Commission Member Document on policy and administrative recommendations for implementing CEAA at the CNSC. It has been given to the CNA and other interested parties for comment and will be presented to the Commission this spring. The document makes recommendations on:

- the delegation of authorities to CNSC staff for implementing processes for complying with CEAA;
- the formalizing of a scoping approval process, including criteria for establishing the scoping authority;
- the formalization of a "screening" EA decision-making process; and,
- the adoption of a public consultation framework for application in the CNSC's CEAA process.

Cost Recovery

The CNA has also expressed concerns about the CNSC's proposed amendments to the Cost Recovery Fees Regulations, which were recently published in the Canada Gazette.

For those of you who are not fully apprised of the details of the cost recovery issue, our website nuclearsafety.gc.ca is a good source for the details.

The CNSC recognizes the CNA as an important association of Canada's nuclear industries. The association's 80-plus members represent about 5 per cent of all CNSC licensees, but the largest percentage of risk-based regulatory effort and, therefore, the largest component of cost recovery.

Through extensive consultations with licensees, the involvement of the CNA and 17 licensees' representatives on the Cost Recovery Advisory Group, or CRAG, we have listened to your concerns. A number of elements of the proposed program have been modified based on the feedback we have received during consultations. We are now in the process of consolidating the feedback we received from the second consultation..

That said, some facts are important enough for me to clearly state today.

Cost recovery is a policy of the federal government, not the CNSC. It is not our decision to recover costs and the fees that are recovered go to the consolidated revenue fund, not to the CNSC. This means that increased revenues from fees does not equate with the CNSC receiving extra budget dollars.

I understand that the view of the Treasury Board Secretariat is that the CNSC has conformed to the federal government's cost recovery and charging policy. Determination of public and private benefits, resulting in the calculation of recoverable and non-recoverable costs, was a key activity in our review of the cost recovery program.

The CNSC has proposed incorporating formulas to enable fees to be updated annually in line with changes in regulatory activity levels and costs, which may result in either an increase or decrease in fees. During consultations many of our 1700 licensees expressed agreement with the concept of a formula to calculate fees, noting that the underlying principles are fair. The proposed new fee structures are designed to reflect the characteristics of the different types of licences issued and the level of effort required of the CNSC in regulating, as well as to recover CNSC costs from the appropriate licensees in the year these costs are incurred. The approach is to manage fees as a key element in an integrated planning, budgeting and cost management process, which is an important element of smart regulation.

The CNSC will prepare annual regulatory activity plans, estimate the cost of those plans, and share this information with licensees. This level of external transparency will provide assurance that the CNSC will ensure its regulatory regime is effective and efficient. The fairness of the proposed structure is that the fees paid by a licensee are relative to the costs incurred in regulating them.

In support of smart regulation, the proposed regulations also have the added benefit of promoting and reinforcing compliance by enabling the CNSC to adjust the fees in accordance with the compliance records of licensees. To increase the objectivity of assessment, the CNSC has formalized a compliance program to help standardize licensee performance requirements and communicate expectations.

I would also like to clarify the question of regulatory standards and "service" standards. The regulatory standard is safety - it is CNSC's legislated mandate and the expectation of our client, the Canadian public. The CNSC's relationship with licensees is not one of service provider and client. The bottom line is that our one and only client is the Canadian public, and we cannot place ourselves in the position of changing

requirements at the behest of industry without there being a safety case.

The CNSC does recognize that standards of effectiveness and efficiency in managing the regulator / licensee relationship are a reasonable expectation, and we are developing Our one and only client is the Canadian public.

such standards and a set of performance measures as part of on-going improvement initiatives. In conjunction with these initiatives, management systems have been put in place to allow managers to accurately track resource use and ensure that resource levels are aligned with risk areas. In fact, to my knowledge, we are the only federal agency or department that tracks time and other costs against projects to this detail.

In comments made by the CNA, it appears that there is a belief that only direct compliance and inspection activities are charged. This is not the case. The CNSC consists of a tribunal with a supporting secretariat, and the corporate services needed to support an agency within federal guidelines, including communications, outreach and intergovernmental affairs.

We also undertake activities that benefit licensees and for which you are not charged. We are a major developed country, and an active participant in international agencies whose activities not only help us to improve as a regulator but are essential to defend Canadian interests. Many CNA members benefit directly from our expert interventions in transport, regulatory devices and environmental standards discussions.

Safety Culture

In past presentations to the CNA, we have made a point of addressing the importance of safety culture in the nuclear industry. I wish to revisit this topic today, due to its currency and importance to the business you are in.

The keys to safety culture are organizational effectiveness, effective communications, organizational learning, and a culture that encourages the identification and resolution of safety issues. The necessity of a strong safety culture places an onus on all of us to continually question whether the safety measures already in place are sufficient, and are being applied.

We have to keep in mind that even with good design and engineering, and with carefully crafted procedures in place, accidents will occur if there is inadequate emphasis on safety culture. We have recently witnessed the results of an inadequate emphasis on safety culture in the United States with the reactor-head degradation at the Davis-Besse nuclear generating station in Ohio.

United States Nuclear Regulatory Commission [former] Chairman Richard Meserve recently stated,

"Plant operations were not conducted in a manner which encouraged a questioning attitude, a commitment to excellence, and the identification and resolution of safety issues. In short, the inspections at Davis-Besse have revealed that the head corrosion problem was a direct result of a degraded safety culture."

Such events have a lasting impression on public perception of both the nuclear industry and the effectiveness of its regulators. We must work to ensure that these events do not happen in Canada.

The regulator can play a role, and the CNSC is doing so, but it is not the primary driver, as no amount or type of regulation can make a licensee's employees live these qualities. The philosophy of Canada's nuclear regulatory regime is that licensees are ultimately responsible for safety, and they are allowed some flexibility to achieve safety. This applies not only to the resolution of technical matters, but also to the fostering, creation, and maintenance of a safety culture. Each organization's leadership has a responsibility to establish priorities, to make the commitment to safety real, and to create a climate in which such a commitment can flourish. It is up to you.

That said, as Canada's nuclear regulator, we are investigating enhanced methods of assessing safety culture. Through reviews of a wide range of facilities, we are trying to get a more complete profile of organizations, identify processes which are working or require improvement, and identify areas for more focused follow-up. We believe that normal regulatory oversight activities should include organizational factors, and licensing decisions should take account of organization and management information relevant to safety performance.

I have questioned Boards of Directors and CEOs on this issue in the past, and there are a number of questions that I will continue to ask, and recommend you ask of yourselves. Is safety a stated primary objective of your organization? Do you have a meaningful safety culture philosophy and program in place? Do you know that it is effective?

International Safeguards

Recent international events have increased the scrutiny of safeguards programs. Responsibility for this lies not only with the CNSC but also with licensees.

A strong non-proliferation regime is necessary to ensure that materials are used only for peaceful uses. With the adoption of the Additional Protocol to Canada's Non-Proliferation Treaty Safeguards Agreement, Canada, and Canada's nuclear industries, are subject to broader and deeper scrutiny by the IAEA. The requirements of the Additional Protocol can be met only through cooperation among the CNSC, the IAEA, and you.

Through a concerted outreach program over the last few years, the CNSC has sought to explain these new requirements to the industry and to obtain its commitment.

Industry has responded positively, but your ongoing cooperation is required, including the need to upgrade certain accounting and reporting measures to meet IAEA requirements. Enhanced transparency of our nuclear fuel cycle, through increased reporting and short notice inspections by IAEA inspectors, strengthens the effectiveness of IAEA safeguards and provides increased confidence in the nuclear non-proliferation regime. Industry must play its role in providing the necessary openness and transparency for safeguards inspections to occur efficiently, accurately and effectively.

In the longer term, the CNSC is working with you to ensure that the IAEA can be convinced that efficiencies are possible under "integrated safeguards." Once the IAEA has drawn broader safeguards conclusions on Canada's nuclear program and infrastructure, the plan will be for reductions in the intensity of IAEA safeguards efforts in certain areas.

Conclusion

These are just some of the issues that are facing both Canada's nuclear regulator and industry.

I would like to close by restating that under Canada's nuclear regulatory regime, licensees who operate in as safe a manner as possible in turn lower the cost of regulation and reduce regulatory burden. There is an onus on licens-

ees to pursue a culture of safety that generates a trust by both the regulator and the public.

I think it is a positive sign that the CNSC / CNA committee continues to work, and it is positive that we have had so much involvement from licensees in the Cost Recovery Advisory Group.

The CNSC does not operate in a vacuum. While our primary client is the Canadian public, we respect the concerns and operational realities of our licensees, and we make all reasonable attempts to reconcile these in an open and transparent manner.

However, in doing so, we have a duty to the Canadian public to carefully guard our independence and to always be mindful of our first and foremost priority, safety.

A conversation with Linda Keen, head of CNSC



Canadian Nuclear Safety
Commission, spoke with the
editor of the CNS Bulletin.
Although her talk at the CNA
Nuclear Winter Seminar is
printed in this issue of the
CNS Bulletin, the focus of
the interview was different.
The following account of the
conversation provides some
insight into the current and
future direction of the CNSC...

On May 7, Linda Keen,

President and CEO of the

Linda Keen

CNS: About a year ago there was a significant re-structuring of the CNSC.

- What was the motivation for the change? What were your objectives?
- Have those objectives been realized?

Keen: The motivation and objective were essentially the same. I wanted the organization to reflect the new Act (Nuclear Safety and Control Act) and the nature of the business of the CNSC.

Although the need for restructuring was not "top of mind" when I was appointed two years ago I did see the need within a few months. My first action was to create an Office of International Affairs and appoint Ken Wagstaff to head it. Our various international obligations and activities were being handled by different parts of the organization and not always properly coordinated.

The second decision was to group Corporate Services,

communication and strategic planning, as an efficiency measure. Also I created the office of Regulatory Affairs under Mike Taylor to handle corporate regulatory matters, maintain our regulatory corporate knowledge and keep us up to date on legislation and government policies. We were too much of an "inside" organization. Within that group we also have an arms length mechanism for internal investigations such as was taken in connection with the licensing of MAPLE.

The creation of the new Secretariat was really important. I have two roles, as President [chair] of the Commission and CEO of the organization. The Secretariat supports just the President and Commission. That is all they do. The Commission even has a different symbol, the "coat of arms" and the secretariat is on a separate floor to maintain independence.

Then, just over a year ago I appointed Ken Pereira as Vice-President of Operations. He is essentially the Chief Operating Officer responsible for all safety matters. I have delegated to him the operation of the "safety" mandate. He basically runs the safety operations, allowing me to serve better as the president of the tribunal, the Commission, because I am not directly involved in the staff recommendations.

After almost two and a half years I now feel reasonably comfortable in the duality of my roles.

Although I am well aware of the staff recommendations I can, as president of the Commission, take a fresh look. I try to be a good chair and allow members to ask questions and fill in with questions which I feel are necessary.

We have asked our Audit and Evaluation Group to review our attainment of objectives of the restructuring and I am pleased with the results to date.

CNS: Could you comment on the relationship of the Commission with the staff.

There is an appropriate relationship. The Keen: Commission members realize that the staff are their advisors. Our process is not adversarial; there is only one person applying for a licence. It is important to note that the Commission members take seriously their role to ensure transparency of the process. That is why they have so open a process with intervenors. There are only two [nuclear regulatory] organizations that have this degree of openness, the NRC [United States Nuclear Regulatory Commission] and ourselves. The Commission members recognize that the goal of the staff and of the Commission is the same, [safety]. In addition, I have an appropriate relationship with the Minister and the Minister's office [of the Department of Natural Resources Canadal in terms of independence of the CNSC and there has never been nor could there be any question about Commission decisions.

CNS: Could we turn to the question of environmental reviews. Many in the industry feel that the requirement for environmental reviews has been excessive. An example was that for just an expansion of the dry storage at the Point Lepreau station.

Keen: First of all let me say that I am comfortable with CEAA [Canadian Environmental Assessment Act] having had considerable background in my previous position (Assistant Deputy Minister, Minerals and Metals, Natural Resources Canada). There is a designated list under CEAA of facilities that must have a comprehensive environmental assessment. For example, the Point Lepreau dry storage facility is on the designated list. We are guided by the CEAA just as we are by the NSCA. The CNSC choice is limited; there is little flexibility. We can determine if the project should be referred to the Minister for a panel review but the Act [CEAA] determines if it is to be a screening or comprehensive one. Although it was before my tenure, I understand that the restart of Pickering A was determined to require a more comprehensive CEAA review primarily because of public concern. On the other hand the restart of the Bruce units 3 and 4 required a screening review.

As I mentioned in my talk to the CNA, the staff is preparing a CMD (Commission Member Document) on environment assessments that will be presented to the Commission and made publicly available later this year. I would add that many (CEAA) delays are caused by incomplete submissions and that we have found that many companies are not fully aware of the CEAA process. I might note that the CEAA review can help in the CNSC licensing process since protection of the environment is part of our mandate.

The required review of CEAA after five years has been completed and the proposed changes have been introduced into Parliament as Bill C-9.

CNS: Last year, in a presentation to the CNS Annual Conference, Tom Viglasky (Director General of the Directorate of Nuclear Substance Regulation at the CNSC) spoke about the application of a "risk-based" approach to the licensing and compliance of radioisotopes. The USNRC has been moving towards "risk informed" regulations for nuclear plants. Is the CNSC going to apply a "risk informed" or "risk based" approach to the licensing and compliance of nuclear power plants?

Keen: Our goal and objective is to have all of the safety compliance and licensing following a risk-based approach. We started with Tom Viglasky's area. In phase 2, we will proceed to apply the approach to the non-power reactor facilities, such as mines, processing facilities, research reactors. We are using a CSA standard as a guide [CAN/CSA Q850 97, "Risk Management: Guideline for Decision Makers"].

Although many use risk management for just resource allocation our goal is to use it both in decision making and resource allocation. We are beginning to look at power reactors, initially using the list of compliance aspects that leads us to licensing decisions. We are also looking at the work of the IAEA [International Atomic Energy Agency] on PSA [probabilistic safety assessment]. But, we are at a very early stage. We did use a risk-based approach on security and we do have a design-basis threat analysis for the protection of major nuclear facilities in Canada.

We are paying attention to the progress by United States NRC and my staff has been to meetings recently about sealed sources in North America. In some areas they are ahead of us but in others we are ahead of them.

In summary, yes we intend to apply a risk approach to power reactors, building on the experience in sealed sources and other facilities. We know it is not easy but we are committed to doing so.

CNS: Are you still a member of the International Nuclear Regulators Association (INRA)?

Keen: Yes. In fact as of a couple of months ago, I am now the chair of the group. We are going to have our next meeting in Saskatoon this September and will be visiting uranium mines in northern Saskatchewan.

CNS: Your predecessor, Agnes Bishop, was one of the first to publicly bring attention to the ageing of the professionals in the Canadian nuclear program. One result is that the nuclear power industry has supported the creation of the Universities Network of Excellence in Nuclear Engineering (UNENE). Is the CNSC participating in UNENE?

Keen: Yes, we are participating in UNENE both through a modest financial contribution of \$30, 000 for each of five years and by offering staff members as lecturers.

To address ageing in CNSC, we have the intern program started two years ago. The first round was very successful with all eight of the interns now in full-time positions with the CNSC, including three at site offices. The second two-year round has begun with six appointees.

We are also cooperating with the CANTEACH program by offering lectures and other appropriate material that we have generated.

I am very interested in research and feel that graduate programs and research go hand in hand. So, support for research at universities is important.

CNS: At the recent CNA seminar you spoke briefly about an Additional Protocol to Canada's NPT Safeguards Agreement with the IAEA. Could you elaborate what this Additional Protocol entails and how it will impact on the operators of nuclear facilities?

Keen: The Additional Protocol extends IAEA safeguards activities to mining and processing facilities and other nuclear activities and permits greater scope to IAEA inspectors. The former affects Canada in particular since we have a great range of nuclear activities. It does require more information from licensees and gives more access to IAEA inspectors, sometimes on short notice. The hope is that it will lead to more effective and more efficient safeguards measure.

CNS: The CNSC appears to have followed the US approach in requiring stringent physical security measures at nuclear facilities, including, I understand, having

armed guards. One effect of this action is the restriction of public visits. Many feel this only exacerbates the public fear of things nuclear.

- Do you still feel that these enhanced security requirements are necessary?

Keen: The measures we have taken are consistent with international standards and the Convention on Physical Protection. We have performed a design basis threat assessment. Our measures started before 9/11 and involve security agencies such as CSIS and the RCMP. We do talk to the US because many of our plants are on international waterways.

Visits have been curtailed because of security and the need for extensive screening. In cases where visitors' centres are established, they will need to be outside the controlled areas.

We believe that the current measures are in line with the risks and will remain in place indefinitely.

There is more information about security measures on our web site < www.nuclearsafety.gc.ca >

CNS: Thank you Ms. Keen.

Keen: It was my pleasure. I might note that I will be speaking at the Annual Conference of your society in June.

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Nuclear Education

Industry, universities and government join in programs to develop and expand the most critical component of our nuclear program - people.

by Fred Boyd

It was about four years ago that Dr. Agnes Bishop, president of the Atomic Energy Control Board (predecessor to the Canadian Nuclear Safety Commission), publicly raised a concern that many in the Canadian nuclear program had discussed privately or in closed circles. Looking at her own organization she observed a fact that was common throughout our program - that her staff was ageing and there were limited numbers of young people studying nuclear science, engineering or technology. The latter problem was one that had been raised by several people in the few universities still offering nuclear studies.

About the same time other western countries were observing the same situation and expressing similar concerns. The various countries have taken different approaches. That followed in Canada is very much a "Made in Canada" program and contains several components.

Fortunately, Bishop's message was heard by leaders of our industry. By 2001 several initiatives were underway, including new scholarships, sponsorship of new Research Chairs, and the proposal for a *Universities Network of Excellence in Nuclear Engineering (UNENE)*.

In 2001 Atomic Energy of Canada Limited entered into an agreement with McMaster University to provide \$10,000 per year for the following five years for a scholarship program. Four scholarships of \$2,500 will be awarded each year for engineering students in their second undergraduate year. Requirements include: outstanding academic standing; demonstrated leadership qualities; an interest in advanced engineering projects. Winners will be offered summer employment or work terms in the year following the award.

The AECL Scholarship awards for 2002-2003 were given to Scott Moore, Engineering Physics and Management, Kevin Solomon, Chemical Engineering and Bioengineering and Avery Yuen, Engineering Physics and Management.

Also in 2001 an *Industrial Research Chair of Fluid Structure Interaction* was established at the École Polytechnique in Montreal with funding from Atomic Energy of Canada Limited (AECL), Babcock & Wilcox Canada (B&W) and the Natural Science and Engineering Research Council (NSERC). Michel Pettigrew, formerly with AECL, was appointed to that position. The primary area of research is the investigation of how the flow of fluids through industrial machinery causes vibration and damage. Direct funding for the five-year project is \$1.5 million, with NSERC providing half and AECL and B & W sharing the other half. Ecole Polytechnique provides laboratory space and services valued at \$375,000.

Subsequently further Industry Research chairs have been

established or are in the advanced planning stage. (See article on UNENE.)

One of those proposed new chairs is at the University of Toronto. Reversing its position of 1997 (when it decided to shutdown its SLOWPOKE reactor) U of T is in the process of establishing an Industry Research Chair in Nuclear Chemical Engineering.

UNENE (the Universities Network of Excellence in Nuclear Engineering) took somewhat longer to get organized. In 2001 Ontario Power Generation (OPG) announced that it was committing \$5 million over five years towards the creation of UNENE, initially in partnership with five Ontario universities - Queen's, Toronto, McMaster, Waterloo and Western. Subsequently, UOIT, École Polytechnique and University of New Brunswick joined the group and a number of other Canadian nuclear industries became co-sponsors along with the Natural Science and Engineering Research Council which provides funding for Industry research Chairs. The intent of the program is to develop nuclear education, research and development capability in Canadian universities. UNENE was incorporated as a non-profit corporation in July 2002

Finally, in 2001, the Province of Ontario announced the creation of a new university, the *University of Ontario Institute of Technology (UOIT)* in Oshawa, which would have a strong program in nuclear engineering.

In parallel with the above activities, a separate but related program, CANTEACH, has been underway, supported by AECL. CANTEACH is described as a "knowledge repository" that provides high quality technical documentation relating to the CANDU nuclear energy system. This information is public and is intended for use in various aspects of education, training, design and operation. It includes the series of lectures organized by George Bereznai, now Dean of Engineering at UOIT, for Chulalingkorn University in Bangkok Thailand, lectures by Dan Meneley at Xi'an University in China, lectures by Victor Snell and others in Shanghai and other material. Dan Meneley, retired chief engineer of AECL, is the program director and Bill Garland of McMaster University, the academic director..

In the following pages there are articles on three of the items mentioned above - UOIT, UNENE and CANTEACH. The first two are based on the presentations by George Bereznai and David Jackson, respectively, at the CNA Annual Seminar in March 2003. (See separate article on that seminar.) The report on CANTEACH was prepared by Bill Garland, Yulia Kosarenko and Dan Meneley. We hope you find them all "educational".

Nuclear Education

UNENE

The University Network of Excellence in Nuclear Engineering will help ensure there are qualified nuclear engineers and scientists for an on-going nuclear program.

Ed. Note: The following article is based on the presentation by David Jackson, program director for UNENE, to the Nuclear Industry Seminar in March 2003 and other related sources.

Background

The average age of employees in Canada's nuclear industry is about 50 years old. Many will be in a position to retire within the next five years. Currently there are not enough students pursuing nuclear programs in our universities to replace these potential retirees. The other side of the coin is that the retirement of these employees means that several thousand attractive and technically challenging positions in nuclear companies will become open, which should entice young people to enrol in nuclear programs.

This situation is an international problem. A 2000 report by the Nuclear Energy Agency of the Organization for Economic Cooperation and Development stated:

"In most countries there are now fewer comprehensive, high-quality nuclear technology programs at universities than before. The ability of universities to attract top-quality students, meet staffing requirements of the nuclear industry, and conduct leading edge research is becoming seriously compromised. Unless something is done to arrest it, this downward spiral will continue."

A report by the CANDU Owners Group (COG), also published in March 2000, recommended that industry and government provide funding to improve collaboration between Canadian universities and the industry. The University Network of Excellence in Nuclear Engineering (UNENE) is one response to providing the highly trained personnel the nuclear industry will require in the future.

Organization

UNENE is an alliance of universities, nuclear power utilities, research and regulatory agencies for the support and development of nuclear education, research and development capability in Canadian universities. It was established as a Canadian not-for-profit corporation with Letters Patent issued July 22, 2002. The nuclear industry has promised over \$8 million over five years. The Natural Science and Engineering Research Council is a partner in the creation of Industry Research Chairs.

The primary objective of UNENE is to assure a sustainable supply of qualified nuclear engineers and scientists to

meet the current and future needs of the Canadian nuclear industry. New nuclear professorships in the associated universities will be established and funding for nuclear research in the universities will be enhanced. In addition UNENE will organize and deliver educational programs appropriate to students planning to enter the industry and to those already employed.

Research Chairs

A number of Industry Research Chairs are proposed in partnership with the Natural Science and Engineering Research Council (NSERC). The participating universities select the areas of nuclear research they wish to pursue, submit these for review by UNENE and, on approval, the industry members of UNENE commit the necessary funds. Then the universities apply to NSERC for funding of the Chairs as Industrial Research Chairs.

An *Industrial Research Chair of Fluid Structure Interaction* has been established at École Polytechnique. Applications have been submitted to NSERC for two other chairs while three more are in the process of seeking appropriate candidates.

Through these research chairs and other mechanisms such as research and development contracts, equipment sharing and cross appointments, UNENE intends to assure continued close contact with the nuclear industry.

Course programs

The initial program is for a course-based Masters degree in nuclear engineering. It is a part-time program designed for those working in the industry who wish to upgrade their qualifications. Courses are in a condensed format given over two extended week-ends separated by about four weeks and can be given at the work site. Students need 10 courses to obtain a Masters degree and can take them over a three year period. Two courses a year is the normal minimum requirement but this can be negotiated if unexpected difficulties make this level temporarily difficult to maintain.

It is possible to take just one course, or a few courses, without completing all the requirements of a degree or diploma. A Certificate of Attendance will be issued on successful completion of a course.

The tuition fee is \$2,500 per course.

As of the spring of 2003 the following courses are being offered by the universities noted.

McMaster

Thermal Hydraulics

Nuclear Power Plant Systems

and Operations **Nuclear Safety** Health Physics and

Radiation Effects

Waterloo

Risk Analysis

Western Reactor control

Instrumentation and

Electrical systems

UOIT

Nuclear Power Plant Systems

and Operations

Queen's

Nuclear Materials Fuel Management

RMC UNB

Reactor Chemistry

École Polytechnique

Reactor Physics

program within their organization, interested persons

should contact the UNENE representatives by e-mail at the

addresses noted below.

Ecole Polytechnique

McMaster University

unene@polymtl.ca unene@mcmaster.ca

Oueen's University unene@queensu.ca University of New Brunswick unene@unb.ca

University of Ontario Institute of Technology

University of Toronto

University of Western Ontario

University of Waterloo

Atomic Energy of Canada Limited

Bruce Power

Canadian Nuclear Safety Commission

CANDU Owners Group

Ontario Power Generation

unene@uoit.ca

unene@utoronto.ca

unene@uwo.ca

unene@uwaterloo.ca

unene@aecl.ca

unene@brucepower.com

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For more information on UNENE courses or on the



Canadian Nuclear Society

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For information on the technical program contact:

Brock Sanderson

Atomic Energy of Canada Limited Chalk River, Ontario, Canada K0J IJ0 e-mail: sandersonb@aecl.ca

For general information or registration contact:

Denise Rouben

Canadian Nuclear Society Toronto, Ontario, Canada

Tel:

416-977-7620

e-mail: cns-snc@on.aibn.com

University of Ontario Institute of Technology

Canada's newest university features programs in nuclear engineering and radiation science

Ed. Note: The following article is based on the presentation by George Bereznai to the Nuclear Industry Seminar in Ottawa, March 2003, augmented by further material provided by him.

Introduction

The University of Ontario Institute of Technology (UOIT) is Canada's newest university. It was established on May 9, 2001 in anticipation of the passing of Bill 139, An Act to Establish the University of Ontario Institute of Technology, which received first reading in the Ontario legislature on November 27, 2001.

Initially UOIT will share a campus and some facilities with Durham College in Oshawa. It has acquired a significant portion of Windfield Farms, which adjoins the Durham College campus and will subsequently expand northwards on the rolling fields famous as the home of the great racehorse Northern Dancer.

The new university is scheduled to open its doors September 2003. A central building is under construction. It will feature wired classrooms and campus-wide wireless for internet and intranet access.

The objectives of the University are:

- "to provide undergraduate and postgraduate university programs with a primary focus on those programs that are innovative and responsive to the individual needs of students and to the market-driven needs of employers;
- to advance the highest quality of learning, teaching, research and professional practice;
- to contribute to the advancement of Ontario in the Canadian and global contexts with particular focus on the Durham region and Northumberland County, and,
- to facilitate student transition between college-level programs and university-level programs."

The University will be governed by the Board of Governors, which has the authority to conduct University affairs, and will also have an Academic Council with the power to make recommendations to the Board on all academic issues.

Although the University does not yet have a faculty complement, it has appointed a Provost and Deans of the seven Schools, all of whom come to the University from other Canadian universities and most of whom have held senior academic administrative positions at these universities. The Provost of the University will be Professor Michael Finlayson, former Chair, Department of History at the University of Toronto and until June 2001, Vice-President (Administration and Human Resources) at the University

of Toronto. Dr. George Bereznai is Dean of the School of Energy Engineering and Nuclear Science.

Degree Programs

The new university will offer four year, honours programs in the following fields:

- Education
- Justice Studies
- Health Science (Nursing)
- · Commerce and Information Technology
- Physical Science
- Biological Science
- Manufacturing Engineering
- Nuclear Engineering
- Radiation Science.

Nuclear Engineering Program

The nuclear engineering undergraduate program at UOIT will be the only stand-alone undergraduate nuclear engineering program to be offered in Canada. It has been developed to complement in content, yet be consistent in quality, with the undergraduate engineering programs offered by other Ontario universities. All other undergraduate nuclear engineering programs are options of other engineering programs, such as Engineering Physics, Mechanical or Chemical Engineering. Review of the proposed curriculum by members of the Program Development Advisory Committee (see below) and other peer reviewers from universities as well as industry have indicated the need for such a dedicated program, and confirmed that the credentials of graduates will be recognized to be on par with the engineering programs of the already established universities.

Located between the two large nuclear power plants of Pickering and Darlington, UOIT is ideally situated to attract students to study nuclear engineering. These power plants and the recently announced move of Ontario Power Generation's nuclear head office staff to Durham Region, will provide challenging and high paying employment for the graduates of the proposed program. Students in the program will have good opportunities for work placements during the course of their studies, and can expect to find rewarding employment at the power plants and with the service organizations in the Region, as well as elsewhere in Canada and internationally.

Although the primary focus of the proposed program is nuclear power plant engineering, the curriculum is sufficiently broad-based that the graduates will be well qualified for a variety of jobs using the many applications of nuclear technology, as well as for a wide range of careers in various energy related fields. The proposed program in nuclear engineering offers options from several other programs that will be offered by UOIT, including radiation physics, manufacturing engineering, science, economics and liberal arts.

The proposed honours baccalaureate degree program in nuclear engineering will commence in September 2003. In the following year, at least one additional baccalaureate degree program, in energy engineering, is planned. A master level program may start as soon as September 2005.

A Nuclear and Radiation Program Advisory Committee has been formed with the following members: Steve Allen, Cameco; Emad Elsayed, OPG; Bill Garland, McMaster; Allen Kupcis, CNA; Brent Lewis, RMC; Grant Malkoske, MDS Nordion; Mohan Mathur, UNENE; Dan Meneley, AECL; Murray Stewart, Iter; Ken Talbot, Bruce Power

Radiation Science Program

The radiation science undergraduate program planned for UOIT has been developed to complement in content, yet be consistent in quality, with other undergraduate physical science programs offered by other Ontario universities. Review of the proposed curriculum by members of the Program Development Advisory Committee has indicated the need for such a dedicated program, and confirmed that the credentials of graduates will be recognized to be on par with the science programs of the already established universities.

Graduates of the proposed Radiation Science program will have the requisite expertise to work and manage the

work of others in one or more fields of application of radiation techniques, including industrial, agricultural, health care, and related facilities. They will be self-directed life-long learners with excellent management and interpersonal skills, and be holistic thinkers, while having core mathematics and science skills. They will also be socially, environmentally, economically and globally aware professional problem solvers, who are familiar with the use of computer hardware and software, and with the ability to seek out information for themselves.

Applications of radiation science include the production and transportation of radioactive materials, the manufacture of products that use radioactive materials, the many uses of the

products made with radioactive materials, the manufacture and operation of equipment that produce radiation by other than radioactive means, the impact of radiation on the environment in general and on the people working in nuclear facilities in particular. Specific industries and applications include radiographic inspection, light sources, food irradiation, sterilization of medical equipment, health physics, medical diagnosis and treatment.

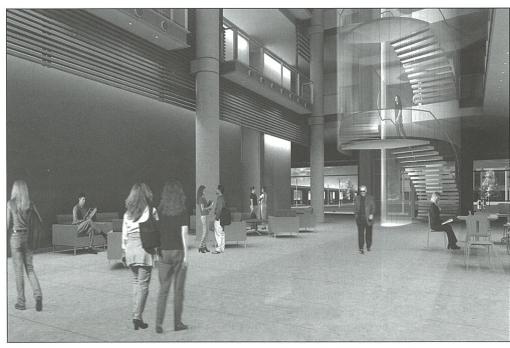
The proposed baccalaureate degree program in radiation science will begin in September 2003. At least one additional baccalaureate degree program, in health physics, is planned for the following year. A master level program may start as soon as September 2005. Also by September 2005, it is expected that graduates of three-year diploma programs in the health care field will be able to enter the third year of a baccalaureate science degree program.

Future Programs

It is planned to add programs in Health Physics and Nuclear Technology in 2004 and Radiation Engineering and Safety and Risk Engineering in 2005.

Research

A research program will be developed consistent with the capabilities of the faculty. It will reflect the needs of industry and institutions and make use of the facilities available at the university. Research chairs are proposed in: nuclear knowledge management; distributed simulation; policy aspects of radioactive waste management; nuclear threat detection; and, public safety.



An architect's drawing of the first building of the University of Ontario Institute of Technology

The CANTEACH Project:

- Preserving CANDU Technical Knowledge

by Bill Garland¹, Yulia Kosarenko², Dan Meneley³

Introduction

Almost sixty years have passed since the nuclear energy venture began in Canada. Fifty years have passed since the founding of AECL. Tens of thousands of dedicated people have forged a new and successful primary energy supply. CANDU technology is well into its second century. This specialty within the world's fission technology community is quite unique, first because it was established as a separate effort very early in the history of world fission energy, and second because it grew in an isolated environment, with tight security requirements, in its early years. Commercial security rules later sustained a considerable degree of isolation.

The pioneers of CANDU development have finished their work. Most of the second generation also has moved on. As yet, we cannot point to a consistent and complete record of this remarkable achievement. We, as a nuclear enterprise, have not captured the design legacy in a form that is readily accessible to the current and future generation of professionals involved with CANDU reactors, be they students, designers, operations staff, regulators, consultants or clients. This is a serious failure. Young people entering our field of study must make do with one or two textbooks and a huge collection of diverse technical papers augmented by limited-scope education and training materials. Those employed in the various parts of the nuclear industry rely mostly on a smaller set of CANDU- related documents available within their own organization; documents that sometimes are rather limited in scope. University professors often have even more limited access to in-depth and up to date information. In fact, they often depend on literature published in other countries when preparing lectures, enhanced by guest lecturers from various parts of the industry. Because CANDU was developed mostly inside Canada, few of these text materials contain useful data describing processes important to the CANDU system.

For many years it has been recognized that a "CANDU Textbook" is needed. However, other work priorities and intense activity within AECL and the utilities have prevented the completion of such a reference volume. There is, in fact, a large volume of existing documents that describe CANDU systems and operations. Too much of that documentation is repetitious and contains less depth than is desir-

able. Very few of the documents detail why CANDU is designed the way it is. How can designs evolve appropriately and how can retrofits and design changes be implemented correctly if the 'whys' are not elucidated? How are the graying experts passing on their knowledge and wisdom? It is this need that the CANTEACH project is striving to fill.

The CANTEACH project has the objectives of (1) capturing the existing legacy non-proprietary documents and images and making them available to all, and (2) distilling the essence of these documents so that the key concepts and the relations between these concepts can be elucidated. the project proceeds, documentation gaps will, no doubt, become evident, prompting a third objective of preparing new documentation. The first objective is as pedestrian as it is necessary. Gathering up the existing documents in an open forum is valid in its own right but it is also necessary for the subsequent tasks of distillation and writing of new documents. The generation of definitive CANDU documents in the public domain will facilitate their subsequent reuse in new documentation preparation throughout the industry. CANTEACH is meant to be a resource for CANDU content. As such, it is a perfect complement to education and training delivery via UNENE, at the utilities, at consulting companies, and at the colleges and universities.

This paper outlines the project, its present status, and its future plans.

History of CANTEACH

The project concept was first developed in China in 1998, in response to the needs of operating staff, engineers, and professors involved in the Qinshan III project. Very little technical information was available in China at that time. Given the ongoing construction schedule, it was obvious that a large education and training program was necessary. AECL staff in Shanghai undertook part of this task, as indicated in Figure 1. The emphasis of this early work is seen

I Bill Garland is a professor at McMaster University, Hamilton, Ontario

² Ylia Kosarenko is on the staff of CANDU Owners Group

³ Dan Meneley, now semi-retired, is a consultant to CANDU Owners Group

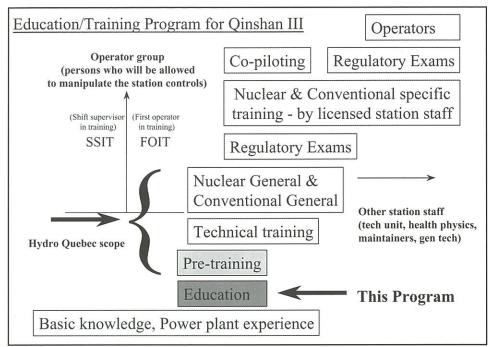


Figure I - Original Role and Place of the Project

at the bottom of that Figure, along with the large number of other education and training programs that contributed to the whole. Success of the whole is indicated by the reliable operation of Unit 1 of Qinshan Phase III (Quinshan 4) and the imminent startup of the second unit. The education project was a very small part of the whole, but contributed significantly to the overall technology transfer goal.

The CANTEACH project was expanded in 2000 and then restructured to make it more appropriate for application in Canada. Administration of the project was transferred to the CANDU Owners' Group in 2002 following the signing of the project agreement by its present partners.

Project Concept

Discussion with individuals and senior managers in Canada in early 2000 led to reformulation of the operating concept of the project. This new concept recognizes that all professionals working in our industry are extremely busy. Furthermore, funding available for this sort of work is very tight. Finally, the number of people both willing and able to write high-quality educational material is quite small.

The driving force for success of this project is the advantage of cooperation. An owner of various packages of information can reduce documentation cost by submitting packages to CANTEACH. A reasonable expectation is that other members of the Project Agreement also will send in their own packages. In this way we avoid the determination of 'exact exchange value' for any given piece of information. Everyone gains by the process, and the body of available information on CANDU increases. The cooperative history of the organizations within the CANDU venture makes this possible.

An essential feature of this document exchange is that it

is voluntary. No member organization is forced to contribute. In this way we avoid trying to do the impossible: that is, to force any member to release confidential or commercially proprietary information. A direct result of this choice of policy is that the information provided to the project tends to be somewhat archival; most documents are those that have been used for some time within the organization and have, as a result, been cross checked for accurate content. This is perhaps the most important characteristic when establishing a set of records useful for education. A second policy that emerges from this choice is that the project is mainly self-funded by the members themselves. Only a very small project staff is required for collecting, organizing, and filing the material. Individuals who wish to undertake larger tasks such as writing of a hard cover textbook may ask for partial funding by the project.

Partners

Fourteen organizations involved in the CANDU industry signed a "good will" cooperative agreement in July of 2001. This agreement was re-signed by all partners in April 2002, to recognize several personnel changes that took place in the interim period. Table I lists the signatories of the CANTEACH Agreement.

The main elements of the project agreement are summarized as follows:

- 1. The CANTEACH Partners agree to develop a comprehensive set of education and training documents prepared according to the highest academic standards to describe the various aspects of CANDU power plant technology. These documents will be subjected to planning and review by the Academic Director and the Project Director, and then will be recommended to the Board of Directors for incorporation into the set of deliverables of the project.
- 2. The CANTEACH Partners will participate in this in a collegial and cooperative atmosphere.
- 3. The products of this undertaking will comprise both print and electronic materials suitable for education and training in the range from high school graduate level to the university post-graduate level.
- All CANTEACH Partners will share in the rights to copy the material contained in the deliverables of the project, provided such copying is for their use in the conduct of their business.

The signatories agreed to a general statement on the subject of copyright, whereby the administrator of the project

Table I - Partners in the CANTEACH Project

Partner Organization	Signatory
Atomic Energy of Canada Ltd.	Dr. David Torgerson (Dr. Paul Fehrenbach)
Bruce Power Incorporated	Mr. Duncan Hawthorne
Canadian Nuclear Safety Commission	Mr. Denys Vermette (Mrs. Cheryl Nelson)
Canadian Nuclear Society	Dr. David Jackson (Mr. Ian Wilson)
CANDU Owners Group	Mr. John Sommerville (Mr. Brian MacTavish)
Ecole Polytechnique	Dr. Rejean Plamondon
Hydro Quebec	Mr. Mario Desilets
McMaster University	Dr. M.A. Elbestawi
NB Power	Mr. Frank McCallum
Ontario Power Generation	Dr. Mohan Mathur (Dr. Emad Elsayad)
Royal Military College of Canada	Dr. Ron Weir
University of New Brunswick	Dr. John Christian
University of Ontario Institute of Technology	Dr. George Bereznai
University of Toronto	Dr. A.N. Venetsanopoulos

(currently the CANDU Owners Group) reserves all rights on behalf of the holders of copyright holders who donate materials to the project files.

Project Model

Figure 2 illustrates the information flow and products of the project. Donors (organizations and individuals) send contributions to CANTEACH staff. The main activities of staff to date relate to development and refinement of the information management system. Results may be judged by browsing the website. Several of the data categories are "under construction"; that is, we have not yet had resources available to populate major portions of the site.

At the present time we are heavily occupied with the task of content generation and organization. There has not been much editing done as yet; a major task yet to be undertaken is content editing for quality. In some cases several versions covering the same subject are available; eventually this diversity will be reduced by merging or by rejection of some materials.

Website Structure and Content

Figure 3, copied from the website home page, serves as an introduction to the features of this site. The contents of the dedicated server containing this information are varied, and they change almost daily as new materials are added. The easiest way to find out what information is available today is to access the website at http://canteach.candu.org. Following are some hints to assist you. If it is your first visit to the site, have a look at "Welcome to CANTEACH".

If you are a high-school teacher, go to the home page and then click "Teacher's Lounge". You will find some

general articles about CANDU along with a rich collection of links to other sites containing a variety of information about nuclear energy. This whole project is "under construction", so that you likely will find many gaps in the files. We are working hard to add materials to all of these records. Look for the contacts given under the HELP DESK icon, and ask, if you need some specific item and cannot find it – we will try to direct you.

If you are a technical staff trainer, you may be looking for any level of data ranging from a single figure to add to a lecture, up to and including a full academic course covering

a particular topic, or the ISBN reference to a textbook on materials science. Exchange of courses and detailed course content between Canadian nuclear utilities has taken place informally for many years and has reduced the training development cost of all organizations involved. The CANTEACH project intends to foster even greater cooperation between utilities, with the objectives of improving the quality of technical information available and reducing the overall cost of developing and delivering requisite training courses.

One large section of course material, originally developed by AECL under contract to the CNSC, recently has been donated to the project. The IAEA has delivered a set of training packages concentrated on illustration of how to operate the plant from the main control panel. Desktop simulators used by IAEA for international training programs also have been donated. It is hoped that these will be made publicly available; versions exist for CANDU, PWR, BWR, and VVER systems. IAEA staff has augmented these

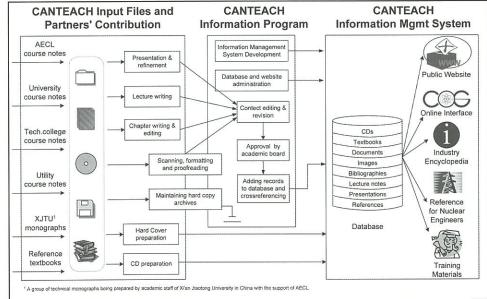


Figure 2. Information Flow and Content

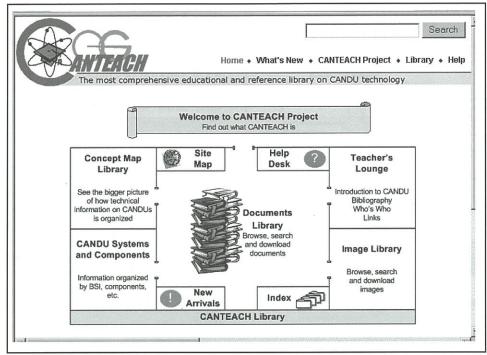


Figure 3 - Reference Library Home Page

programs through development contracts, issued mostly to the original code developers.

If you are a university professor you likely will be looking not only for detailed descriptions of CANDU systems and processes, but for discussion of the underlying logic that led to some of the thousands of choices made in the design and operation of the CANDU nuclear electric generating system. All materials in the system are available for download and copying into your lecture notes or to those of your students. Links may be of particular value to students working on research projects related to the nuclear industry around the world.

If you are a senior manager you might be trying to judge the value of CANTEACH, and whether or not it should be given continued funding support. The most direct response is to give some idea of the basic costs of developing high quality technical information of this sort. First, the cost of one person-year of a senior technical expert is about \$150,000 per year. Second, the typical ratio of time for development of a single university-level course to the delivery time of that course is between 5:1 and 10:1. One single-term course, then, will cost about \$30,000 to develop. Maintenance and updating of such a course adds at least another \$5,000 per year.

So, if your staff exchanges one course instead of developing a new course in-house, your cash saving will be in the neighborhood of \$20,000. In addition, exchange of such courses adds a bonus in quality improvement – difficult to quantify, but probably important. An added value derives from the fact that the information is public and can be used by all those people working on the CANDU enterprise. This feature results in a further reduction of cost, again difficult

to quantify, that arises through more efficient education and training of non-utility staff and instructors.

You may ask: "How long must this project go on?" The CANTEACH project staff estimates that it will take about 10 years to properly document the existing set of education and training information, with an annual project cost in the range of \$250,000 per year. However, recognizing that this field is still developing and new information is becoming available each year, it may be of benefit to the CANDU enterprise to continue the project indefinitely at a modest, 'maintenance' level of funding.

Completed Activities:

Some of the major items gathered and posted to date include:

- Extensive training material from the CNSC
- The 1972 Symposium series from AECL
- Presentations and reports from AECL
- CANDU Origins and Evolution documents by emeritus retirees
- Heavy Water Reactors: Status and Projected Development Technical Report by the IAEA
- Links to the full content for many of the McMaster nuclear courses
- List of all nuclear engineering courses in Canada, with links where applicable
- A small image library that we will be expanding.

Supporting all this is, of course, the design and construction of the information system itself. Authoring tools have been researched and the schema has been formulated and implemented.

Current Activities

The database

The CANDU material currently on the web site is static. The library page contains a simple listing of the documents sorted by institution. The user, however, may wish to re-sort or filter the documents by author, date, keyword, system, etc. To add this capability, a database is being constructed and coupled with a web-driven database engine to allow the user to sift and sort the document library. The following figures illustrate some of the dimensions that we are building into the database.

This hierarchy of keywords specific to CANDUs in several dimensions would be of great value to the CANDU community

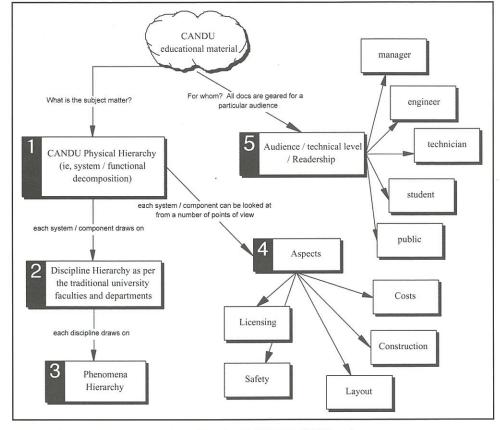


Figure 4 Keyword Dimensions for the CANTEACH Database

in general, quite apart from its use in CANTEACH. Discussions are underway with COG to coordinate CANTEACH keywords with COG's Information Management System.

Filing and archiving

Behind the simple and clean CANTEACH user interface to the library lays the non-trivial task of document management. Archives for source files are maintained, documents under review are held in a restricted web area pending acceptance and editing to prepare them for the web. Archiving and record management will remain an important function of the project, and the documents database is developed with that in mind.

Formatting complex documents

Since the CANTEACH library documents come from various sources and has to cater to different audiences, the issue of document format had to be resolved to provide consistency and modularity. All documents are posted in Acrobat PDF format to enable consistent reading and printing without loss of the document format and to enable the use of complex page layouts, something that web browsers cannot currently provide. This is important for legacy documents so that historical accuracy can be maintained. Currently large and complex documents such as courses and books are formatted so that they can easily be copied to different media as "modules" consisting of several cross-referenced

Acrobat documents. There is no need of complex web browser or service files such as tables of contents. The whole module can be copied "as is" to a CD, desktop or company's Intranet. Archival copies of all documents in their native format are kept and can be made available upon demand for re-purposing.

Future Developments

In the near future, look for the database system to be enabled on the website. This will permit sifting and sorting of the document listings, a welcome and necessary addition as the library grows.

Recently, Ontario Power Generation has agreed to the release of the older versions of the fundamentals training courses that are ubiquitous in the Canadian nuclear industry. We are in the process of scanning these documents for posting to the web site. This is an important contribution both because these legacy courses have been the backbone of utility training for so many years that they need to be preserved for

historical reasons and also because their presence on the web site signals an important and welcome contribution from the utilities. We will be posting Burnham's fabulous Radiation Protection book in the near future and we have an Instrumentation and Control course waiting to be edited for the web. The 36 courses given at Chulalongkorn University, Thailand a few years ago will also be posted one by one as permission rights are granted and as time permits.

In time, derivative documents are planned to provide a distillation of the key concepts and relations in CANDU design and operation. It is planned to produce small, focused document sections rather than monolithic 'books' so that reusability and re-purposing is enhanced.

Summary

The CANTEACH project exists to provide access to existing legacy education and training documents and images, to distill the essence of these documents and to prepare new documentation. The partnership agreement between the key stakeholders is in place, the initial web delivery platform is in place and the task of populating the CANTEACH library with seminal documents is underway. The underlying philosophy of an open and free, cooperative exchange of fundamental CANDU design and operation information has proven to be sound. Do take the time to visit the CANTEACH library. We look forward to hearing your comments and suggestions after you visit the CANTEACH web site.

Acknowledgements

The authors wish to thanks all those individuals who have kindly donated to CANTEACH and the Partner institutions for their continuing support.

References

1. The CANTEACH web site can be found at http://canteach.candu.org.



The March 7, 2003 meeting of the CNS Council was the first time it was possible to obtain a photograph of all of the 2002 - 2003 executive.

L to R Bill Schneider, 2nd VP; Walter Thompson, treasurer; Ian Wilson, president; Ben Rouben, secretary; Jeremy Whitlock, 1st VP; David Jackson, past president.



Canadian Nuclear Society

6th International CANDU Maintenance Conference

Holiday Inn On King Hotel, Toronto, Ontario
16 - 18 November 2003

"Maintenance for Life"

This conference will provide a forum for discussion and exchange of information on all aspects of maintenance relevant to CANDU nuclear generating stations, particularly those addressing issues relevant to maintenance in a competitive, open market environment.

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NPD:

- Canada's First Nuclear Power Station

by Lorne McConnell¹

Ed. Note: As part of our on-going "history" series we reprint this paper originally presented at a special session of the 23rd CNS Annual Conference held in Toronto, June 2002. It has been slightly edited to suit this form of publication.

Commemoration

Forty years ago, on June 4, 1962, NPD produced and delivered to Canadian consumers the first electricity in Canada using nuclear energy as the primary energy source. This plenary session at this CNS Conference is part of the celebration of this Canadian historical event.

During this past weekend I enjoyed the opportunity to participate in two other events near the site of NPD at Rolphton, Ontario. As most of you may know, NPD, which stands for Nuclear Power Demonstration, was the first major stage in the highly successful Canadian nuclear-electric program in Canada.

Fig. 1 is a photograph taken early on April 11, 1962, the day the nuclear reactor first started (went critical).

Deep River was the residential community of Atomic Energy of Canada Limited (AECL) employees located at Chalk River, Ontario and later was the residential community for Ontario Hydro employees who operated NPD and its associated Nuclear Training Centre. It was appropriate that the beginning of this 40th year celebration start at Deep River, Ontario for two reasons:

- (1) First, the Canadian nuclear-electric program is based on the CANDU- PHW (CANadian Deuterium Uranium - Pressurized Heavy Water) concept which was conceived between 1955 and 1958 at the Chalk River National Laboratory (CRNL) of AECL located a few miles from Deep River.
- (2) Second, NPD was located on the Ontario bank of the Ottawa River also a few miles from Deep River.

I personally knew and admired the contributions of many hundreds of people in Canada and from abroad who contributed to the Canadian nuclear program and in particular to the development, design, construction, manufacturing and operation of NPD. Because of my 20 minute presentation limitation, I have chosen to talk about 'what was done' and 'why it was done' and not talk about 'who did it.'

My presentation is divided into 6 parts as follows:

- 1 Before NPD (1939 to 1955)
- 2. NPD1 Started Building (1955 to 1958)
- 3. Ontario Hydro and AECL Studies (1955 to 1958)
- 4. NPD1 Cancelled and NPD2 Built (1958 to 1962)
- 5. NPD2 Experience (Starting1962)
- 6 Two Retrospective Commentaries

Part I - BEFORE NPD (1939 to 1955)

World War 2 - 1939 to 1945

The Chalk River National Laboratory was created during World War 2. The USA nuclear bomb program had two major thrusts: (a) to build nuclear bombs using uranium-235 extracted from natural uranium in an enrichment plant and (b) to build nuclear bombs using plutonium-239 produced in low flux graphite moderated reactors. The Canadian-British program undertook the more certain but slower path to build nuclear bombs using plutonium-239 produced in heavy water moderated reactors. During the war, NRX, which stands for National Research Experimental, had two objectives:

- (1) the military objective I have just described and
- (2) provide a research facility to advance nuclear science.

Although NRX was designed and constructed during World War 2, it did not start up until 1947 some 2 years after the end of the war. NRX was the world's first high flux nuclear reactor and it featured heavy water as a moderator and natural uranium metal as a fuel. It was fitted with many superb experimental features subsequently used for early Canadian, British, and American development. NRX was a key facility in advancing nuclear science in Canada and the world. NRX proved the high amount of energy that could be produced per kilogram of natural uranium in a heavy water moderated reactor. Note: The energy available from natural uranium in a graphite moderated reac-

Lorne McConnell retired as a senior vice-president of Ontario Hydro. He was the first superintendent of NPD.

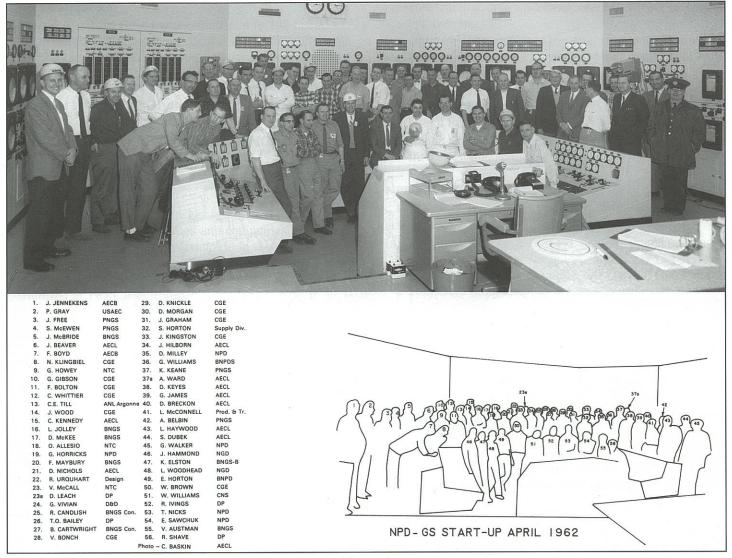


Figure I

tor is much lower than a heavy water moderated reactor and a reactor will not function with natural uranium and a light water moderator. This high energy availability per kilogram of natural uranium in heavy water moderated reactors became the cornerstone of the subsequent CANDU-PHW concept. The result is a very low fuelling unit energy cost, which results in economic production of electricity.

USA Nuclear Submarine - Late 1940s

In the late 1940s the USA Navy undertook to design and build a nuclear submarine, called the Nautilus. This submarine featured a pressure vessel, a light water moderator and enriched uranium fuel. The testing of the fuel was done in NRX, at that time the only high flux reactor in the world. This was done in a high pressure, high temperature loop. Important lessons were learned which established the proper approach to controlling the conditions in the heat transport system. The experiences from the operation of this high pressure, high temperature test loop had a major influence on NPD in establishing:

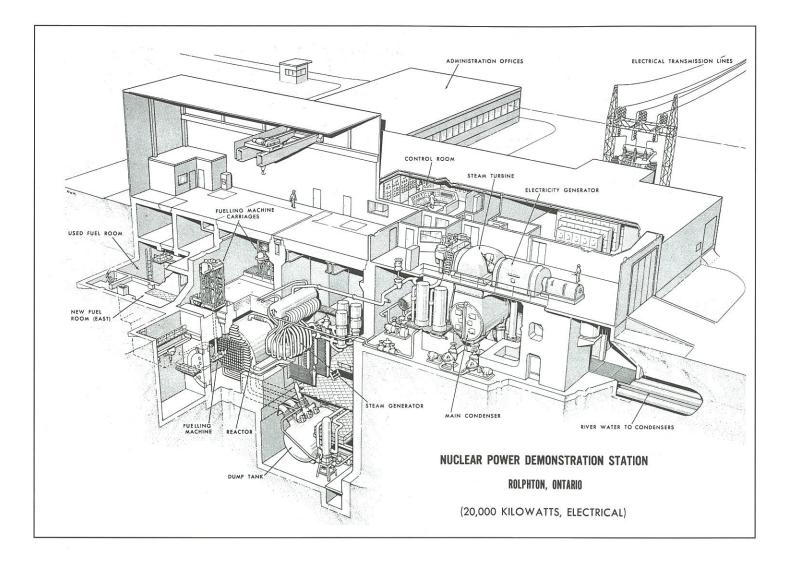
- the design parameters (pressures, temperatures etc.)
 and
- the operating chemical controls to manage the erosion and corrosion of the heat transport system.

NRX Incident - 1952

In 1952, at NRX, a zero power fuel burnup measurement was being conducted which required that the normal water cooling of some fuel rods be temporarily replaced with air cooling. During this measurement, an unintended power excursion occurred which resulted in the rupture of these air cooled fuel rods. Following an investigation of the causes of this accident, a set of design and operating safety principles was developed, to ensure there would be no repeat of such an event. This accident had a major influence on the design of the control and safety systems in all subsequent nuclear reactors in Canada including NPD.

Ontario Generation of Electricity - 1900 to 1950

During the period from 1900 to 1950, Ontario Hydro suc-



cessfully developed and built many low total unit energy cost hydro-electric generating stations that contributed to the industrial success in Ontario. Similar successful hydro-electric programs were established in Quebec, Manitoba and British Columbia. However, in Ontario, the undeveloped economic hydro-electric capacity was small compared with the forecast need for future electricity demand.

Thus about 1950 Ontario Hydro started committing a series of thermal-electric generating stations burning coal produced (mined and processed) in the USA. Also about 1950, Ontario Hydro became interested in the development of nuclear-electric generating stations using natural uranium which was, in general, indigenous to Canada and in particular, indigenous to Ontario. In the later full scale Canadian nuclear-electric program, this indigenous natural uranium:

- increased Canadian mining, refining, and manufacturing jobs:
- improved the balance-of-trade; and,
- reduced the cost of electricity to consumers.

Peaceful Uses of Nuclear Energy - Post World War 2

When World War 2 ended, Canada decided to discontinue

its military nuclear objectives and pursue the peaceful uses of nuclear energy. Two major thrusts were established:

- (a) the production of radio-isotopes, and,
- (b) the production of heat and electricity.

Atomic Energy of Canada was created in 1952 by a Federal Act to pursue these peaceful objectives.

In the early 1950s both the USA and the UK had committed the construction of nuclear-electric generating stations and plans were being developed in other countries such as France, Germany, USSR and Japan.

Private Enterprise Competition

The USA (United States Atomic Energy Commission) and United Kingdom (United Kingdom Atomic Energy Authority) were committed to the development of nuclear electric generating stations using competitive design and supply companies. Up to 1950, thermal-electric generating units were typically up to 50 MWe units in size but thousands of MWe were required to meet future demands.

Canada decided to follow the lead of the USA and the UK and pursue the establishment of competing private companies to design and construct nuclear-electric generating stations.

1954 Study Group

A Nuclear Power Group was established in 1954 at AECL that produced a general basis for the design of a 20 MWe demonstration plant and an associated capital cost estimate. In addition to five AECL employees, this group included nine persons seconded from public and private companies. It was supervised by an Ontario Hydro manager.

Part 2 - NPD1 STARTED BUILDING (1955 to 1958)

NPD Committed - 1955

In the early 1950s, Atomic Energy of Canada solicited proposals from all of the utilities and companies in Canada (both private and public) to participate in the development of a nuclear-electric program. Based on the solicited proposals and the results of the 1954 Study Group, NPD1 was committed in 1955, it featured:

- an electric capacity of 20MWe,
- a vertical pressure vessel,
- a heavy water moderator,
- natural uranium dioxide fuel, and
- off-power fuelling.

These features were directly the result of the foregoing experiences in Canada namely:

- (a) NRX the natural uranium heavy water moderated reactor:
- (b) the experiences in the operation of the high pressure, high temperature loop for the American submarine program and
- (c) the design and operating safety principles which were formulated subsequent to the 1952 NRX incident.

Canada had experience in NRX with both natural uranium metal fuel and natural uranium oxide. Natural uranium oxide fuel was selected because it had superior corrosion resistance and dimensional stability characteristics in spite of the fact that uranium metal had the potential of a lower fuelling unit energy cost. At that time Canada had some experience with the use of thorium and uranium 233. Canada also had some experience with enriched uranium 235 fuels operating in sodium potassium heat transport. AECL had also performed considerable research and development for the UK on the irradiation of graphite in the NRX reactor. AECL was not attracted to graphite reactors because of the lower fuel burnup and the dimensional instability of graphite.

The responsibility for the development, design, construction and operation of this unit was as follows:

- (a) AECL continued to perform the necessary research and development and paid for most of the cost of the nuclear steam generating system.
- (b) The Canadian General Electric Company, Civilian Atomic Power Department (CGE-CAPD) designed the nuclear steam generating system, oversaw the plant

- construction, and undertook manufacturing of certain components.
- (c) Ontario Hydro provided the site, designed the balance of plant, paid for the balance of plant, and was to commission and operate the station.
- (d) Ontario Hydro was to reimburse AECL for all energy produced at a rate based on what Ontario Hydro would have paid if the electricity had been generated from coal.
- (e) Public tenders were solicited from private enterprise for the design and supply of most of the plant components.

NPDI 1955 to 1958

During the period from 1955 to 1958, the following actions took place:

- (a) to support the design of NPD, AECL research and development continued at Chalk River augmented by development by CGE in Peterborough and Ontario Hydro development at the Dobson Research Laboratory in Toronto.
- (b) most of the design of NPD1 was completed by the Canadian General Electric Co. at Peterborough and Ontario Hydro in Toronto.
- (c) most plant components had been ordered through competitive tender and were in an advanced stage of manufacture.
- (d) the construction of the plant was underway and was being performed by Canadian Bechtel Ltd. under the direction of GGE.
- (e) the key operating staff had been recruited by Ontario Hydro and a rigorous training program established.

By 1958, it was clear that the final cost would be much greater than the original estimate of about 8 million dollars. A cost review was performed which indicated the cost would be closer to 34 million dollars.

Part 3 - ONTARIO HYDRO AND AECL STUDIES 1955 TO 1958

Ontario Hydro Planning 1955 to 1958

During the 1950s Ontario Hydro had built or committed coal- fired, thermal-electric units with capacity sizes of 60 MWe, 100 MWe, 200 MWe and 300 MWe in multi-unit generating stations. During the period from 1955 to 1958, Ontario Hydro planners concluded that electricity from coal-fired generating stations in Ontario would be most economic if generated in multi-unit generating stations, with units up to 500 MWe capacity under consideration - far greater than the 50 MWe units built up to 1950. Such large unit, multi-unit stations, posed a major economic challenge to the Canadian Nuclear-Electric program.

Atomic Energy of Canada Studies 1955 to 1958

A second AECL team at Chalk River called the Nuclear Power Group, led by an Ontario

Hydro manager, studied the economics of alternative

nuclear-electric concepts between 1955 and 1958 while NPD1 was being built. The studies of this team resulted in a nuclear-electric generating station concept which promised a lower electricity total unit energy cost than a large coal-fired thermal-electric multi-unit station in Ontario.

The following major conclusions resulted from this study.

- (1) It became clear that a nuclear-electric generating station using a pressure vessel, heavy water moderator and natural uranium fuel had little or no hope of economically competing with large unit, coal-fired stations in Ontario or elsewhere in Canada. The long migration length of neutrons in a heavy water moderator required a pressure vessel larger than required for light water reactors.
- (2) This new concept called CANDU-PHW (CANadian Deuterium Uranium-Pressurized Heavy Water) developed by this team promised competitive nuclear-electric power for base load applications. This concept featured: a heavy water moderator, zircaloy pressure tubes rather than a pressure vessel, natural uranium dioxide fuel, and bi-directional on-power fuelling in a horizontal reactor.
 - Zirconium Niobium Pressure Tubes were introduced at a later stage of the Canadian nuclear program (Pickering units 3 and 4).
- (3) The study suggested the Total Unit Energy Cost from a nuclear-electric station from a second large sized commercial nuclear generating station would be economically competitive with alternative coal-fired stations.
- (4) Uranium is indigenous to Canada and would substitute for the ever increasing amounts of coal from the USA.
- (5) During the early 1950s, an intense high level of public environmental concern had developed in Ontario because of the emissions of particulates, sulphur dioxide, and nitrous oxides from coal-fired generating stations.

Nuclear Power Plant Design Competition Not Viable

Considering the small population in Canada and in particular in Ontario, Ontario Hydro concluded that only a few large unit, multi-unit, nuclear or thermal-electric stations would be required to meet electricity requirements in the foreseeable future in Ontario and Canada.

Ontario Hydro and AECL subsequently concluded that two or more than two competitive nuclear power plant designers in Canada was not a viable alternative. Note: Other countries, with populations larger than Canada, such as the UK and France, reluctantly came to the same conclusion many years later.

Part 4 NPD1 CANCELLED AND NPD2 BUILT (1958 to 1962)

NPD1 Cancelled and NPD2 Committed 1958

In 1958, Atomic Energy of Canada and Ontario Hydro

made an agonizing set of decisions. But in hindsight, in my opinion, they were good decisions.

- (1) The design and construction of NPD, now known as NPD1, was terminated.
- (2) NPD2 was committed which featured the new CANDU concept with a heavy water moderator, zircaloy pressure tubes, natural uranium dioxide fuel, a horizontal reactor, and on-power fuelling.
- (3) The plan to establish competing private nuclear design and construction companies in Canada was abandoned.. Future designs were to be supplied by one national agency.

The Nuclear Power Plant Division of AECL was established in Toronto and proceeded immediately with the design of the 200 MWe Douglas Point Prototype station. At that time I personally knew every person in the Canadian General Electric design team which was called the Civilian Atomic Power Department. This department employed many highly competent people. Naturally, they were very disappointed with this decision.

- (4) Planning studies were initiated regarding the possible early commitment of a commercial Multi-Unit Nuclear Electric Station featuring 500 Mwe units.
- (5) A target was set to design, construct and commission NPD2 by 1961, a very ambitious 3 year design and construction target for such a new concept.
- (6) The responsibilities for the research & development, design, construction, commissioning and operation for NPD2 were to be the same as for NPD1.
- (7) The pressure tubes were a critical unproven component of the CANDU- PHW concept. It was assumed that the pressure tubes would be replaced after 15 years of operation.

This CANDU-PHW concept became the major thrust of the Canadian Nuclear Program.

However, Atomic Energy of Canada continued to study and develop other concepts that featured alternate heat transport such as organics and boiling light water.

Part 5 NPD2 EXPERIENCE (Starting 1962)

NPD2 In-Service Date

I have already mentioned that NPD2, or if you wish NPD, produced first electricity on June 4, 1962. In steps, it was raised to the full power of 22 MWe and was declared In-Service on October1, 1962. The In-Service date was late by 1.3 years.

CANDU Concept - Major Concerns - 1958

When NPD2 was committed, some of the major concerns were as follows:

1. Would it be practical to build a heat transport system to operate at high pressure and high temperature, or would

- the loss of high cost heavy water make it economically impractical?
- 2. Would the pressure tubes be reliable? Would they meet the original 15 year target life before replacement?
- 3. Could pump seals be developed to operate at high pressure and high temperature without significant heavy water losses?
- 4. Could reliable on-power fuelling machines be developed?
- 5. Could high pressure boilers to transfer heat from heavy water to ordinary water be built at reasonable cost?
- 6. Would the nuclear fuel yield high burnup and low failure rate?
- 7. Would the reactor be safe for the public and workers?
- 8. Would this concept of CANDU -PHW lead to economically competitive electricity cost in large commercial units operating on base load?

Prove Technical Viability

NPD provided the proof the CANDU-PHW concept was technically a viable method of producing electricity. This was an important communication to:

- senior members of Atomic Energy of Canada;
- senior members of Canadian Utilities and in particular to Ontario Hydro;
- politicians in Canada and in particular to the Federal Government and to the Province of Ontario;
- and most important, the Canadian public.

Heavy Water Upkeep Cost

One of the major questions about the CANDU-PHW concept was whether or not the heavy water losses and heavy water upgrading costs would be economically acceptable. The early operation of NPD2 demonstrated that the initial design of NPD2 was not acceptable and that the cost of heavy water losses and upgrading was too high. The plant operators initiated a major modification to the plant by having a Heavy Water Vapor Recovery System installed. The new approach to the future was (a) take all practical economic measures to minimize heavy water leakage and (b) recover both liquid and vapor heavy water leakage. Subsequent operations over many years in NPD2 and later stations proved that the cost of heavy water upkeep was economically acceptable.

On-Power Fuelling

The first successful on-power fuelling was achieved on November 23,1963. Some features of the first on-power fuelling design were satisfactory and some features were not satisfactory. A new Mark II on-power fuelling machine design was developed by the Canadian General Electric Company for NPD2. This Mark II design was installed in 1969 and was highly successful.

Fuel

The NPD fuel bundle performance was excellent in

respect to reliability and cost and proved the soundness of the design, estimated high burnup, and manufacturing process. Later bundle designs for the commercial units were larger and required some additional development work.

Performance Measurement System

NPD2 established a comprehensive set of objectives and a system of performance measurements. These quantified measures pertained to: employee safety, public safety, production reliability, environmental protection and total electricity cost. This system of objectives and performance measures was maintained at all future stations. Performance results were fed back to senior management, planners, designers, manufacturers, and research and development. Engineers with operating experience were attached to the design organization to review and comment on new designs.

Performance Improvements

Deficiency reports were recorded for each event that reduced the performance associated with any objective. These deficiency reports were analysed and the following actions taken:

- (a) Modifications in design, equipment, operating procedures and training were made to improve future performance.
- (b) Feedback was given to researchers, developers, designers, and manufacturers, which included identification of deficiencies and in some cases suggestions for improvement of future stations.
- (c) Many persons with operating experience later became employees of design organizations.

Employee Safety

Employee worker safety targets were established and the results were measured every year at NPD2 and subsequent nuclear stations. The targets required that employees on the average be safer at work than not at work. This included the risk of radiation exposure. I know of no other major industry in North America that had a better worker safety performance than nuclear-electric stations in Canada (average Canadian performance for the entire nuclear-electric industry during the 40 year period from 1962 to 2002). I have been advised that USA nuclear-electric performance in recent years has exceeded the Canadian performance.

Public Safety

NPD2 led the way in both design and operations to establish a risk analysis and measurement system to ensure acceptable public safety. The world nuclear-electric industry has suffered a lot of bad press as a result of the Chernobyl Accident in the former USSR and the 3- Mile Island Accident in the USA. However, the Canadian record for public safety during the first 40 years has been better than any other major form of electric generation (considering deaths, life shortening and health impairment).

It is my opinion or judgement or speculation or whatever

else you wish to call it, there will be more but infrequent nuclear accidents in the western world but that in the long term nuclear-electric generation will continue to have a superior public safety record per kWh than other major forms of electric generation.

The nuclear-electric program must consider public safety and environmental protection during the entire lifecycle from uranium mining up to and including disposal of radioactive waste. During and prior to World War 2 there were uranium mining, processing and refining activities in Canada that had serious adverse consequences. However, the competitive Ontario Hydro procurement program for uranium fuel required high safety standards to be met during mining and manufacture. Ted Bazeley will be talking about this program later in this plenary session.

Reliability

NPD sacrificed its capability factor performance to permit equipment and fuel development, testing and operator training. The causes of lost production were identified and the causes of these problems were fed back to designers and manufacturers. The lessons learned at NPD contributed to the high reliability performance achievements in subsequent nuclear generating stations in Canada.

Comprehensive Cost Records

A Uniform Subject Index was established as a design, construction, commissioning, operating and accounting base for NPD2 and subsequent nuclear-electric units. A comprehensive cost reporting system was established. Note: NPD2 did not prove that CANDU was economically competitive for base-load application. This proof had to wait until after the large commercial units were started.

Pressure Tubes

In 1958, the CANDU-PHW concept assumed a 15 year economic lifetime of the pressure tubes. However, many researchers, designers and operators had come to believe the lifetime would be much longer. In 1958, when NPD2 was committed, the concept of zircaloy high pressure, high temperature, pressure tubes with low neutron capture was unproven. NPD2 was used not only to monitor the performance of pressure tubes but also for development of new pressure tube designs and materials. NPD2 did not give advance warning of the first pressure tube failure in Pickering in 1983. In NPD, the pressure tubes were a smaller diameter, were subject to a lower neutron flux, and had a different design of spacers separating the pressure tubes from the calandria tubes.

Part 6 TWO RETROSPECTIVE COMMENTARIES

Retrospective Views

I know that my knowledge of the current nuclear program

is somewhat obsolete. Nevertheless, the word 'retrospective' was used in conjunction with this plenary session - what did we learn from our past experiences. Accordingly before closing, I would like to offer two retrospective commentaries.

Atomic Energy Control Board (Now the Canadian Nuclear Safety Commission)

NPD, the first nuclear-electric generating station in Canada was also the first nuclear-electric unit that was required to be reviewed and approved by the Atomic Energy Control Board (AECB). I strongly support the concept that Canada and other nations should have a truly competent independent regulatory authority to review and approve the operation of nuclear-electric stations and its associated activities. I understand why the design and operating staff of AECL and Canadian utilities have sometimes been frustrated with the slowness and the decisions of the AECB, and in fairness I understand the reverse to be equally true. I am not so naive that I would expect such frustrations of applicants and regulators can be totally eliminated.

To be responsible in meeting their mandate, the AECB has faced a very difficult challenge and many competent people in the AECB have worked hard to meet this challenge. I would like to encourage future staff in Canada's nuclear regulatory authority to remember that no form of generation has or will have perfect public safety or perfect environmental protection. I understand and appreciate the need for the nuclear industry and the regulatory agency to have some deterministic or prescriptive criteria but suggest they be kept to a minimum. I prefer the emphasis be a risk based approach that was first established at NPD.

Unjustified additional requirements (costs) imposed on the nuclear industry by any agency will in the long term result in a shift between alternative forms of generation and may thereby result in increased worker and public deaths, life shortening or health impairment if the alternative forms of energy have less imposing requirements. In other words, I am suggesting that total society risk is most important and urge future regulatory staff to keep this in mind.

I hasten to add that both the Canadian nuclear industry and the Canadian regulators must continue to pursue and achieve high standards of public safety and environmental protection.

Nuclear Operations Staff Recruitment and Training

At NPD2 a Nuclear Training Centre was established. This training centre had the following responsibilities:

- (1) To recruit the right kinds of people and the right numbers of people to meet the requirements for all nuclear operating positions at all locations at the right time.
- (2) To manage the initial training of all nuclear operations employees.
- (3) To manage the training and qualification programs of nuclear operations personnel.

This centre provided the recruitment and training for all kinds of positions at the operating stations such as operators, maintenance, technical staff, supervisors, chemical control, and managers.

The planning, recruitment, and training requirements was a formidable task to meet the rapidly expanding requirements beyond NPD: Douglas Point, Pickering A, Bruce A, Pickering B, Bruce B and Darlington as well as training services provided to other Canadian utilities and overseas projects. The staffing also had to consider the extra requirements during the commissioning, provide trainers, and meet special demands for activities such as retubing.

The Nuclear Training Centre was provided a staffing plan each year, which forecast the required numbers of staff, for each position, for each location. The training of personnel included real shutdowns, change of power levels, and startups of NPD. High standards of qualification were established and met. At a later stage in the program, station simulators were built, and other advanced training centres were built. This was a vital program to contribute to the past high performance of Ontario Hydro's commercial nuclear stations during the 1970s and 1980s.

The disruption of this recruitment & training program and the decimation of the Ontario Hydro's trained nuclear staff in the latter part of the last century is another story.

My first hand knowledge of Ontario Hydro operations, including nuclear operations, ended in 1982. My knowledge of events during the period from 1982 to 2002 is second hand. Based on the foregoing, it is my current opinion that this nuclear training failure was, in general, not due to actions or inactions of the managers directly responsible for nuclear operations. The resulting inadequate operating staff was a major contributor to the reduced nuclear performance of commercial nuclear stations during the 1990s and the decision to shutdown eight large commercial units in 1997.

In retrospect, and regardless of who was at fault in the past, this nuclear training failure experience reinforces the following comments:

- (1) it is absolutely vital that operating staffs responsibly: plan, recruit, train and qualify the necessary people on schedule
- (2) it is equally imperative that the corporate directors and senior staff in the responsible organization: endorse, approve and support the implementation of plans that will ensure the needs are met..
- (3) senior management may impose cost restraints or budget cuts based on a critical analysis that has been conducted with care and thoroughness.
- (4) a corporation operating one or more nuclear units that makes ruthless arbitrary cuts across an entire corporation is acting irresponsibly.
- (5) The Total Unit Energy Cost in a base load nuclear generating station is very sensitive to the achievement of a high capability factor and it makes sound economic sense to have an operating staff that can achieve good reliability results. Unwarranted reductions in operating staff reduces the OM&A costs (operations and maintenance costs) but simultaneously increases the total costs to the electricity customer.
- (6) I presented a paper at the Sixth Pacific Basin Nuclear Conference September 7-11, 1987 called "A Recipe for Nuclear Operations Success". I believe that recipe is still valid today.

CLOSING

In closing, I would like to thank the Canadian Nuclear Society for this opportunity to share in the celebration of this 40th Anniversary of NPD.

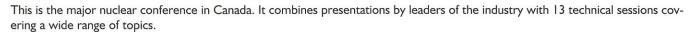


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An Advanced Direct Cycle High Temperature Gas Reactor

by: Ralph S. Hart¹, James M. Kendall², Barry J. Marsden³

1.0 INTRODUCTION

The MOTHER (MOdular Thermal HElium Reactor) power plant concepts employ high temperature gas reactors utilizing TRISO fuel, graphite moderator, and helium coolant, in combination with a direct Brayton cycle for electricity generation. The helium coolant from the reactor vessel passes through a Power Conversion Unit (PCU), which includes a turbine-generator, recuperator, precooler, intercooler and turbine-compressors, before being returned to the reactor vessel. The PCU substitutes for the reactor coolant system pumps and steam generators and most of the Balance Of Plant (BOP), including the steam turbines and condensers, employed by conventional nuclear power plants utilizing water cooled reactors. This provides a compact, efficient, and relatively simple plant configuration.

The MOTHER MK I conceptual design, completed in the 1987 - 1989 time frame, was developed to economically meet the energy demands for extracting and processing heavy oil from the tar sands of western Canada. However, considerable effort was made to maximize the market potential beyond this application. Consistent with the remote and very high labour rate environment in the tar sands region, simplification of maintenance procedures and facilitation of 'change-out' in lieu of in situ repair was a design focus.

MOTHER MK I had a thermal output of 288 MW and produced 120 MW electrical when operated in the electricity only production mode. An annular Prismatic reactor core was utilized, largely to minimize day-to-day operations activities. Key features of the power conversion system included two Power Conversion Units (144 MW $_{\rm th}$ each), the horizontal orientation of all rotating machinery and major heat exchangers axes, high speed rotating machinery (17,030 rpm for the turbine-compressors and 10,200 rpm for the power turbine-generator), gas (helium) bearings for all rotating machinery, and solid state frequency conversion from 170 cps (at full power) to the grid frequency.

Recognizing that the on-power refueling feature of the Pebble Bed reactor core concept is attractive in many situations, the MOTHER MK II conceptual design adopts a Pebble Bed core configuration. The power conversion systems of MOTHER MKI are utilized. In an effort to overcome the disadvantages of current graphite pebble annular Pebble Bed core designs, MOTHER MK II introduces a novel split core configuration.

The MOTHER concepts were developed with an objective of minimizing technical risk and the need for technology

development. A principal purpose of this paper is to inform other designers currently working on direct cycle HTGR concepts of the work undertaken in defining the designs for the MOTHER nuclear power plants, and of the many novel technical features adopted.

2.0 BACKGROUND

Early development of the High Temperature Gas Reactor (HTGR) was undertaken under the OECD Dragon project, which began in 1959 and involved the participation of thirteen nations. The Dragon project resulted in the development of the first BISO and TRISO particle fuels, and in the world's first prismatic type HTGR (Dragon), built at the Winfrith Atomic Establishment in Great Britain. Development of the HTGR was centered in Germany and the USA from the late 1960s through the 1980s, with demonstration and commercial units being built in both countries.

Both the German and US modular HTGR concepts developed in the 1980s take advantage of the TRISO fuel particles (Figure 1). TRISO fuel particles, with an outside diameter of less than one mm, consist of a uranium, plutonium oxide, or oxycarbide kernel with four coatings. The porous pyrolytic carbon inner layer accommodates fission gasses and fission product recoil. The high density inner pyrocarbon protects the kernel during application of the silicon carbide layer and serves as a barrier to fission product gases and

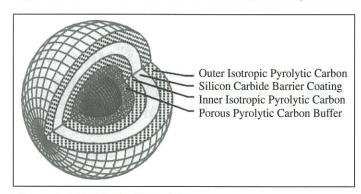


Figure 1: TRISO Fuel Particle

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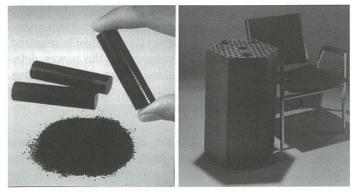


Figure 2: Prismatic Fuel Element

a secondary structural element for internal pressure. The high density outer pyrocarbon protects the silicon carbide layer during fuel element pressing and also serves as a barrier to fission product gases and a secondary structural element for internal pressure. The silicon carbide coating serves as the primary barrier against diffusion of metallic fission products and serves as the primary structural element for internal pressure. The radionuclide retaining capability of the TRISO particle is maintained up to high temperatures, with 1600°C typically used as a design limit under accident conditions.

The German designed HTGR plants utilize a "Pebble Bed" core; TRISO particles, enclosed in a graphite matrix, are contained within billiard ball sized "Pebbles" which occupy the reactor core volume within an annular graphite reflector structure; the helium coolant flows through the Pebble Bed to remove the heat of fission. The Pebble Bed HTGR is refueled on-power; the pebbles flow slowly downward in

the reactor vessel, and are removed via a discharge port located at the bottom of the reactor vessel. The pebbles are remotely inspected when discharged; depleted fuel pebbles are directed to the spent fuel storage facilities, while the remaining fuel pebbles and graphite pebbles (if utilized) are returned to the top of the reactor vessel. New fuel pebbles are added to compensate for the depleted fuel pebbles discharged.

The HTGR plants designed by General Atomics in the USA have a prismatic core, consisting of hexagonal graphite elements that contain columns of fuel and coolant flow passages, surrounded by a radial graphite reflector. The TRISO fuel particles are contained within a graphite matrix in fuel compacts that occupy vertical wells in the fuel elements (Figure 2). The TRISO fuel

particles (lower left) are formed into fuel compacts (upper left); the fuel compacts are then inserted into vertical wells in the prismatic graphite fuel elements (right). Prismatic core HTGRs are batch refueled off-power.

Inherent shutdown is achieved in modular HTGRs, primarily by the strong negative reactivity temperature coefficient of the graphite moderator. Passive fuel cooling is provided following postulated accident conditions by the conduction and radiation of heat from the high temperature capability TRISO fuel to the pressure vessel surroundings; this requirement, in conjunction with fuel and pressure vessel temperature limits, places restraints on the size of prismatic core modular HTGRs to about 600 MW_{th}, and limits coolant core outlet temperature to about 950°C.

3.0 MOTHER TECHNICAL OVERVIEW

The combination of Reactor Unit (RU) and Power Conversion Units (PCUs) is referred to as the Main Power System (MPS). A common helium inventory serves as coolant for the RU and the working fluid for the PCUs. The heat of fission produced within the reactor vessel is transferred to the helium reactor coolant that is circulated upward through the reactor core; the helium coolant subsequently passes through a PCU to generate electricity via a closed Brayton cycle, before being returned to the reactor vessel. The cycle thermodynamic efficiency is estimated at 42%.

The RU includes the vertical cylindrical steel reactor pressure vessel and the pressure vessel internals, the reactor auxiliary systems, the reactor regulation and shutdown systems, and the on-power refueling system.

The PCUs include all of the major equipment utilized for the circulation of helium coolant through the RU and for the

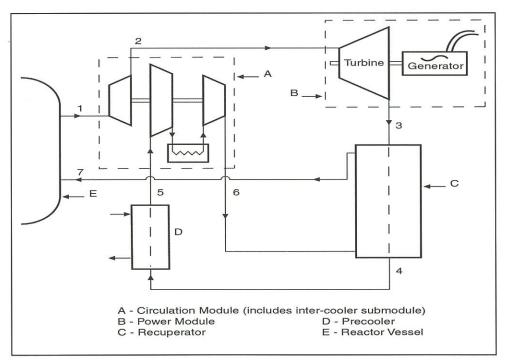


Figure 3: Power Conversion Unit - Simplified Flow diagram

Table I: Power Conversion Unit Circuit Conditions			
Location (refer to Figure 3)	Temperature ° C	Pressure MPa	
1 Reactor outlet	910	7.2	
2 Power Turbine inlet	710	4.5	
3 Recuperator low pressure inlet	520	2.7	
4 Recuperator low pressure outlet	145	2.5	
5 Precooler outlet	35	2.4	
6 (High Pressure compressor outlet	105	7.4	
7 Recuperator high pressure outlet	525	7.2	

production of electricity from the thermal energy produced by the reactor. This equipment includes the low pressure first stage compressor and the high pressure second stage compressor together with their drive turbine, the power turbine and generator, the recuperator, the precooler, the intercooler, the connecting pipes and associated pressure vessels and the PCU control systems. A simplified flow sheet for a PCU is presented in Figure 3; the helium conditions at key points in the PCU circuit are given in Table 1.

Upon leaving the reactor, (1) in Figure 1, the hot highpressure helium is expanded in the compressor drive turbine to state (2) after which it is further expanded in the power turbine to state (3). From (3) to (4), the helium is cooled in the recuperator, after which it is further cooled in the pre-cooler to state (5). The helium, at low pressure and temperature (5) is compressed by the Low Pressure (LP) compressor to an intermediate pressure, after which it is cooled in an intercooler before entering the High Pressure (HP) Compressor, where it is compressed to state (6). From (6) to (7), the helium is preheated in the recuperator before entering the reactor which heats the helium to state (1).

Approximately 3/4 of the vertical cylindrical steel reactor pressure vessel is housed within an underground silo. The direct cycle facilitates the upward flow of helium through the reactor core, and the location of the PCU equipment at or near the operating deck elevation (the area surrrounding the pressure vessel at ground elevation).

A number of valves, not shown in Figure 1, are required to provide reliable operation of the PCU. These include:

- Power Turbine Bypass Valves: The PT Bypass Valves, which are located in lines connecting the HP compressor discharge and the LP compressor inlet, are used in the case of load rejection. These fast acting valves open to ensure that the power turbine-generator does not overspeed, and close to keep the Brayton cycle in operation. The primary purpose of the valves is equipment protection rather than power control. The Power Turbine Bypass Valves also form part of the Reactor Protection System. There are fivePower Turbine Bypass Valves in each PCU; these valves are normally closed, and function in either the open or closed position.
- Compressor Bypass Valves: The Compressor Bypass

Valves have two main functions. First, to control power during some load following conditions and normal operation. For this function, stringent flow control is required. The second function is to ensure that the power delivered by the Generator stabilizes during a load rejection. For this function coarse control is required. Two fine control valves and two coarse control valves are provided in each PCU.

- Recuperator Bypass Valves: The recuperator bypass valves are used when decay heat is being removed from the reactor. These valves are opened to bypass the recuperator and ensure that the helium returning to the reactor does not absorb the heat coming from the reactor in the recuperator, allowing the removal of heat in the pre-cooler. There are three valves, all with coarse control.
- Compressor Thermal Valves: The primary function of the Compressor Thermal Valves is to ensure that the temperature of the helium going to the LP compressor turbine, the power turbine, and the Recuperator does not exceed specified limits. The opening the valve allows cold helium from the helium suply manifold to mix with the hot gases leaving the HP turbine so that the gas temperature at the inlet to the Recuperator is maintained within the design range. This valve is used during load rejection and system conditioning modes.

In the short term, load following over a range of +/- 15% of the operating power level is acomplished by varying the speed of the power turbines; the frequency converter is 'locked' to the grid frequency, and controls the speed of the turbine generator in accordance with the power regulation alogorithim. For long term load changes and larger short term changes in load, which includes all cases for which the maximum rate of load change does not exceed 10% of full power rating per minute and the MPS helium inventory exceeds 35% of the helium inventory level associated with Full Power Operation (FPO), is achieved through the use of the Inventory Control System, which can add or to remove helium mass from the Main Power System, thereby increasing or decreasing the average pressure in the system.

As the pressure changes, the average density of the helium in the Main Power System also changes, which in turn changes the mass flow rates through the reactor, turbo-machines and heat exchangers. By increasing or decreasing the mass flow rate, the power level can be increased or decreased with minimal change in cycle temperatures or the rotational speeds of the turbine units. This provides maximum efficiency at power levels for which the helium inventory level of the Main Power System exceeds 35% of the FPO helium inventory

At low power levels, load following is achieved at minimum inventory (35% of FPO inventory) utilizing the compressor bypass valves. Opening any number of these valves results in a fraction of the total system mass flow bypassing the reactor and power turbine, thereby reducing the generator power output. By varying the number of valves that are

opened simultaneously, the rate of change in power output can be controlled. Unlike the inventory control method of power control, opening the bypass valves results in changes in cycle temperatures and the rotational speeds of the turbine units.

Load rejection (loss of line) is the most severe design basis operating transient for the power turbine-generator. In this situation, fast acting switch gear connects the generator output, bypassing the frequency converter, to a bank of resistors that maintain the electrical load on the generator; this action in combination with operation of the compressor bypass valves, prevent excessive overspeed of the generator and generator drive turbine while reactor power is being reduced.

A helium pressure control system is provided for the generator cavity of each PCU; this system includes triplicated pressure measurements at each side of the labyrinth seals located between the turbine and generator cavities and regulated reliable high purity helium feed into the generator cavity, to assure the there is no contamination of the generator cavity helium by helium from the reactor Main Power System.

4.0 PCU DESIGN CONSIDERATIONS

4.1 General

Comprehensive design requirements were established for MOTHER MKI, many directed at ease of maintenance and component change-out, which strongly influenced the design; the latter included the ability to transport all major modules except the RU via heavy lift helicopter, and the ability to transport all rotating machinery modules via Twin Otter aircraft. Risk analyses were completed throughout the design process, and every effort was made to avoid design features that had a high risk and/or a long development period. A conservative approach was followed throughout the design process; this is evidenced for example, by the use of two 50% capacity PCUs in lieu of a single 100% capacity unit. Although not fully reflected in the sections below, the design process was iterative, progressing toward the final design.

4.2 Helium Operating Fluid

Helium has a very high Mach number (roughly three times that of air). Hence, all turbine blading flow regimes in the PCU are significantly subsonic. This is in contrast to modern steam turbines and air cycle gas turbines, which typically operate with the tips of turbine blade in the trans-sonic flow regime. As a result, the design of the power/drive turbines for the PCU is relatively simple and straightforward. In addition, the helium remains a gas as it passes through the PCU, thereby avoiding the erosion and corrosion problems encountered in the low pressure stages of steam turbines. It is anticipated that the helium flow through the PCU turbines will be relatively clean, thereby reducing the erosion by particulate material entrained in

the flow relative to an open cycle air turbine.

The use of pressurized helium as the generator cooling and insulating medium avoids the requirement for pressure retaining seals between the turbine and generator cavities and the explosions risk associated with the use of hydrogen. Although there is very limited information available on the performance of pressurized helium in this application, analysis indicates that helium, which has a high heat capacity and low viscosity, is an excellent generator coolant. However, the windage losses are substantially greater than those for low pressure hydrogen. Tests confirmed that helium also has excellent electrical insulation properties, provided that it is free from contaminates such as moisture and graphite particles.

4.3 Speed Of Rotating Machinery

The use of low speed (3600 rpm) rotating machinery was evaluated and several risks and difficulties were identified. These included:

- Massive equipment sizes. For example, the 60 MWe power module weight was estimated at 18 tonnes, far exceeding transportability requirements,
- A requirement for magnetic bearing since gas bearings are not viable at low speed; there is no experience world-wide with magnetic bearings in the required size range, and concerns with thermal differential expansion in the bearings were identified,
- Dynamic concerns were identified for arrangements with three radial magnetic bearings on a single shaft; two bearing arrangements were not considered to be practical,
- Magnetic bearings require "catcher bearings" with the capability of sudden loading at full speed; the design of catcher bearings in the required size range was considered very demanding and unproven.

The use of high speed rotating machinery (greater than 10,000 rpm) was also evaluated and several advantages were identified. These include:

- The feasibility of highly reliable gas bearings of simple and proven design,
- Compact equipment sizes (for example maximum blade outside radius of 60 MWe power module turbine is 19.6 inches; the power module weight was estimated to be less than 6 tons).
- The feasibility of backup roller bearings for all rotating machinery for use during run-up to speed and shutdown
- Back-up helium supplied to bearings from gas bottles on loss of normal redundant helium supplies, is effective in minimizing wear on the roller bearings,

The normal speed of power module turbine-generator is limited to 10,200 rpm (with 20% overspeed allowance) by generator structural considerations. Advanced generator designs are expected to allow for a significant increase in generator rotational speed and/or size.

It was concluded that all rotating machinery should operate at the maximum feasible rotational speed, consistent with aircraft turbine engine practice.

4.4 Orientation Of Rotating Machinery

Positioning of the rotating machinery with the axis of rotation in both vertical and horizontal orientations were evaluated. Horizontal orientation was selected based on the following benefits;

- Modules operate in the about the same orientation as they are in when shipped for initial construction and for overhaul,
- Positioning of rotating machinery modules at or near the operating deck minimizes site excavation, facilitates ease of maintenance and "change-out", and minimizes material handling requirements,
- No offsetting advantages were identified for vertical orientation of the lightweight high speed rotating machinery.

4.5 PCU Configuration

The use of two 50% capacity PCUs was adopted as a prudent and conservative approach for the first generation of MOTHER nuclear power plants, given the novelty of many PCU components, and the many design challenges presented by the PCU components. In addition, component size is substantially reduced relative to that required with a single 288 $\rm MW_{th}$ PCU, which is more compatible with project component transportation requirements.

A three shaft PCU configuration was initially considered, with the low and high pressure compressors and their drive turbines on independent shafts, to facilitate maintenance and change-out of the modules. However, dynamic system analysis indicated a high risk of flow instability in the system since there is no mechanical coupling between the three rotating shafts; only the speed of the power turbine-generator shaft is controlled through the synchronization of the generator with the grid via the frequency converter. This risk resulted in the current two shaft configuration, with both compressors and their drive turbine on one shaft, being adopted; dynamic analysis indicated that this configuration is stable.

4.6 Recuperator Configuration

The principal function of the Recuperator is to transfer the heat energy in the gas stream exhausted from the power turbine, to the gas stream flowing from the high pressure stage compressor. The Recuperator is the source of approximately 55% of the heat that is transferred to the helium as it flows around the MPS circuit, with the reactor contributing the remaining 45% of heat transferred to the helium. Hence, the recuperator must achieve high heat transfer efficiency while incuring low pressure drop in order to acieve high cycle efficiency and operation with low pressure ratio compressors. The recuperator was considered to be the most challenging aspect of the MOTHER design.

A modularized all welded plate type recuperator design, consisting of 8 subassemblies, was developed. The design facilitated the exchange of individual subassemblies. The subassembly size also permits performance to be confirmed by full scale tests.

5.0 CORE CONFIGURATION DESIGN CONSIDERATIONS

5. I General

MOTHER MK I adopted an annular prismatic core design of the type developed by General Atomics, largely because it does not incorporate on-power refueling, a feature which increases the day-to-day operational duties. Other advantages of the prismatic core configuration relative to the Pebble Bed core design identified include higher core power density and reduced excavation requirements during construction. However, the on-power refueling feature of the Pebble Bed core design avoids the need for periodic refueling outages, and facilitates operation with a minimum of excess reactivity in the core; these advantages may justify the additional complexity in many situations. Hence, MOTHER MK II focused on the development of a simplified Pebble Bed core configuration that minimized both capital and operational costs.

5.2 The Annular Core

A prime objective of current high temperature reactor concepts (for example, GT-MHR, PBMR, and MOTHER) is to provide the inherent ability to passively reject decay heat to the environment in the event of the coincident failure of all active systems provided for heat removal and reactor power control, sufficient to prevent significant TRISO fuel particle failures. Since decay heat must be transferred from the fuel to the reactor vessel and hence to the environment via radiation, conduction and natural convection while maintaining fuel temperatures within acceptable limits, this objective constrains the physical size/output of the reactor.

To facilitate an increase in reactor size, General Atomics developed the 'annular core' concept, which incorporates a column of graphite reflector blocks in the center of the reactor core. This graphite column, which is maintained at a relatively low temperature during normal operating conditions, serves as a heat sink during the early stages of postulated accidents and eliminates the temperature peak at the center of a cylindrical core, thereby preventing overheating of the TRISO fuel particles during the time required for the reactor to shutdown via the strong negative temperature coefficient, and for decay heat production to fall below heat loss from the vessel.

Some current pebble bed reactor concepts emulate the General Atomics annular core concept by introducing a column of graphite pebbles in the center of the reactor core. Although this allows for an increase in reactor size/output, it has several disadvantages; these include high helium core

bypass (about 25% of the helium passes through the graphite pebble column, bypassing the fuel pebbles), a complex and costly on-power refueling system, and no provision for control or shutdown rods in the central core region. There is also a concern over the flow of fuel and graphite pebbles through the core, and the mixing of fuel and graphite pebbles as they move toward the reactor vessel outlet.

5.3 The Spit Core Configuration

The MOTHER Mk II design effort resulted in the definition of a **split core** design, which introduces a graphite divider (central reflector) that spans the reactor core, dividing the reactor core into two semicircular columns of fuel pebbles (Figure 4). Under the accident conditions postulated above, the graphite central reflector, consisting of a stack of interlocking structural graphite beams supported by the graphite radial reflector, acts as a heat sink and also serves to conduct heat from the central core region to the radial reflector.

The graphite central reflector beams have a rectangular cross section. Projections from the upper beam surfaces and corresponding cavities in the bottom beam surfaces locate the beams and ensure the dimensional stability of the central reflector. These 'keys' have sufficient clearance to accommodate differential thermal expansion and dimensional change over the operating life of the central reflector, with consideration of accident conditions; axial clearances at the keys are the minimum at the center of the beams and increase toward the ends of the beams. The ends of the central divider beams interlock with the graphite radial reflector blocks to provide structural integrity and to minimize neutron streaming. The bottom central reflector beam has an inverted cathedral cross section that assures uniform Pebble flow from the bottom of the core.

The beams composing the upper third of the central reflector consist of two sections (one section is one third length and the other section is two thirds length), stacked so that their interlocking axial joints alternate; this facilitates replacement of the central reflector at end of life. Further work is required to optimize the configuration of the central reflector. Recent analysis indicates that widening the central region of the central reflector while thinning the end portions, which gives the vertical pebble bed core sections a slight kidney shape, is beneficial.

Core physics analysis confirms that a strong neutronic coupling of the two core segments is provided in the split core design, and demonstrates the stability and controllability of the reactor core. In the reference 288 MW_{th} MOTHER MK II design, all control rods are located in the radial reflector; shutdown rods are located in the radial reflector and central reflector. Relative to a prismatic core of comparable size, the **split core** configuration has a reduction in fuel burnup of about 1%, largely due to an increase in neutron leakage at the central reflector and radial reflector intersections.

In addition to the helium that bypasses the core directly

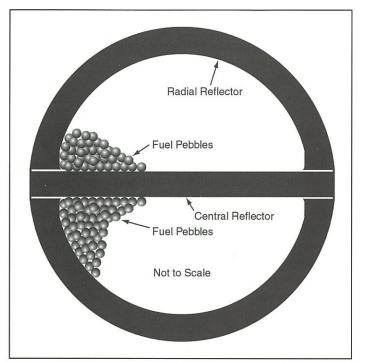


Figure 4: Simplified Cross Section of Core Graphite Structures

via flow through the reflector blocks, helium cross-flow in the radial reflector and central reflector due to gapping caused by cross block thermal gradients and dimensional changes occurs. Estimates for core bypass flow in MOTHER MK II are 17% via the radial reflector and 8% via the central reflector. Estimates of cross-flow are 4% for in the radial reflector, and 2% for the central reflector. Total bypass, and cross-flow is therefore expected to be 31%. This is thought to be about the same as for an annular prismatic core of comparable power output, and about 25% less than for an annular Pebble Bed core.

The fabrication of the graphite central reflector beams demands careful attention. A possibility investigated is to produce the beams utilizing graphite fibers. This methodology was demonstrated through the production of test specimens using commercial graphite fibers. The graphite fibers were coated with a graphite slurry (the same composition as used in fuel compact production), and placed in an alloy steel mould (about 250 mm long with a 13 mm wide slot); a piece of bar stock was then placed on top of the bed of coated fibers, and substantial pressure applied to produce a 13 mm square graphite beam.

The assembly was then baked to solidify the graphite mixture, and then baked in a ceramic furnace with an inert atmosphere at high temperature to crystallize the matrix material. These beams were then machined to provide specimens for tensile testing; the two beams tested had tensile strengths above 250,000 psi. The beam tensile strength was predicted to decrease by between 60% and 70% over 25 full power years of operation; on this basis, the design life of the central reflector was conservatively

set at 20 years. Further work is required for scale up and to establish the effect of irradiation on graphite properties; other fabrication technologies should also be investigated.

The benefits derived from the **split core** configuration relative to cores with the central column of graphite pebbles include:

- The on-power refueling system is greatly simplified since there is no need to separate graphite pebbles from fuel pebbles and return them to the reactor, and the number of fuel pebble return lines required is reduced to two from about nine as there is no requirement to distribute the fuel pebbles around an annulus,
- Maintenance accessibility is improved since a large number of Pebble return lines, which must be shielded and insulated, causes considerable congestion in both the region around the upper section of the reactor vessel and in the fuel handling system area,
- Control and shutdown rods can be accommodated within the central reflector as required,
- Helium flow active core bypass and cross-flow is reduced to about 31% from more than 50%,
- Core power density and/or helium outlet temperature is facilitated by the reduced core helium flow bypass,
- Elimination of uncertainties related to the flow distribution and possible mixing of graphite pebbles and fuel pebbles in the graphite pebble annular pebble bed core, and,
- More uniform core helium outlet temperature resulting from the reduced core helium flow bypass.

6.0 POWER CONVERSION DEMONSTRATION

Risk analysis of the MOTHER MK I nuclear power plant design indicated that about 80% of the project technical risk was accumulated by the components of the Power Conversion Units; although a high degree of confidence existed in the design of all PCU components, they were recognized as being highly novel and not supported by significant relevant operating experience. Since the first MOTHER MK I unit was likely to operate in a remote and high labour cost environment, the importance of minimizing technical risks and avoiding startup and operational delays was recognized.

In order to largely eliminate PCU related technical risks prior to the construction of the first MOTHER nuclear power plant, plans for the construction of the Power Conversion Demonstration (PCD) facility were developed. The conceptual design of the PCD included one complete 144 MW_{th} Power Conversion Unit; *identical* in all respects to the PCUs proposed for MOTHER, and a coal fired helium heater, which substituted for the reactor. A prototype supercritical boiler design, with minor design modifications, was adopted as the helium heater.

The PCD design was capable of confirming the performance of all PCU components, including the frequency

converter, major auxiliary systems including the inventory control system, and the PCU control systems under the full range of reactor operating conditions.

The planned in-service date of the PCD was 30 months following the date of commitment; construction of the first MOTHER unit was anticipated to start following one year of reliable operation of the PCD, or about four years following commitment of the PCD. This period was comparable to the time required for the anticipated licensing process and did not impact the project critical path.

The estimated overnight capital cost of the PCD was 48 million 1990 US dollars; this cost was considered to be small in comparison to the risk reduction benefits realized. Nuclear power plant commissioning and operational delays are very costly, particularly after the unit has been fueled. Resolving technical problems following criticality can be extremely costly. Although the PCD is particularly attractive for the MOTHER application considered as it could be constructed and operated in a relatively low cost environment, the PCD was is to be a prudent step in the development of the MOTHER nuclear power plants, regardless of where the first unit was to be constructed.

7.0 SUMMARY

MOTHER MK I introduced a number of unique concepts in the Power Conversion Units, including the horizontal orientation of all rotating machinery and major heat exchangers axes, high speed rotating machinery (17,030 rpm for turbine-compressors and 10,200 rpm for power turbine-generator), gas (helium) bearings for all rotating machinery, and solid state frequency conversion from 170 cps (at full power) to the grid frequency (50 cps or 60 cps). MOTHER MK II introduces the split core configuration, which simplifies the on-power refueling system for Pebble Bed reactors and facilitates an increase in core power density and/or core outlet temperature.

Many of the technical features of MOTHER were considered to be novel at the time they were developed since there was very little prior work published relating to direct cycle HTGRs at that time; they are considered novel today since they depart significantly from the approaches followed by current direct cycle HTGR designers. This paper reviews the technical features of the MOTHER nuclear power plant concepts, and briefly discusses the major design considerations. The Power Conversion Demonstration, designed to minimize PCU technical risks, is also discussed. The authors hope that some of these features will be considered for commercial direct cycle HTGR units.

7.0 ACKNOWLEDGEMENTS

The authors wish to acknowledge the valuable contribution of Pratt and Whitney Canada Ltd., which completed the evaluation and design of all the turbo-machinery for MOTHER MK I, under the capable direction of Mr. Harry Keast.

GENERAL news

Flooding at McArthur River Mine

While developing a new drift at the huge McArthur River uranium mine in early April 2003 a major inflow of water incurred which exceeded the capacity of the pumps. This led to flooding of the grinding equipment located at the lowest level of the mine.

Additional pumps were installed and by early May the flooded equipment had been uncovered.

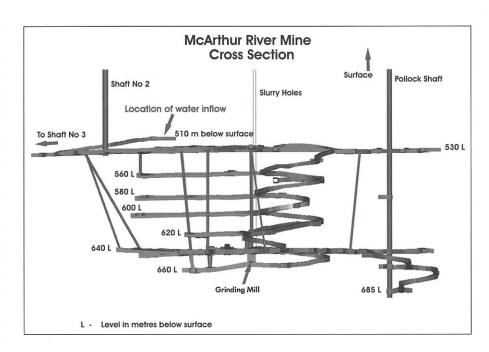
Most of the pumping capacity is located on the 530-metre level below surface. The critical area of the mine, located 640 metres below the surface, contains the ore processing equipment and large pumps that would be lost if total mine pumping capacity does not keep up with the water inflow.

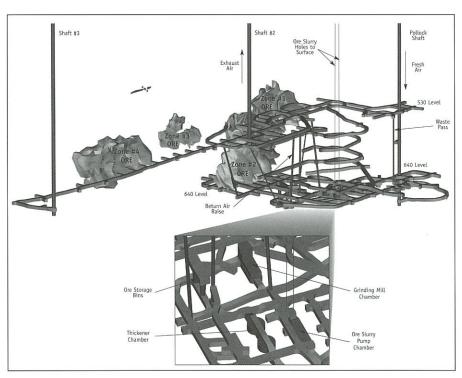
A concrete barrier was constructed in the new drift to stop the inflow of water into the working sections of the mine and fractures are being sealed. As of early May, Cameco officials expected that production would resume in August.

The McArthur River mine is in northern Saskatchewan about 620 km. (by air) north of Saskatoon. Last year McArthur River mine produced about 60 per cent of Canadian uranium production, which amounted to about 20 per cent of world production. Cameco Corporation, the operator of the mine is also the largest owner, with about 70 per cent. Cogema Resources Inc owns the remainder.

The following two figures give a picture of the mine workings and the location of the inflow relative to the grinding equipment.

See the article "McArthur River Uranium Mine" in Vol. 22, No. 3, October 2001 issue of the CNS Bulletin for a description of the mine and unique mining techniques.





AECL Restructures

As of April 1, 2003, the beginning of its fiscal year, Atomic Energy of Canada Limited has a new structure.

The operations of the company have been divided into five "business units", each headed by a vice-president, as follows: Customer Relations & Sales Business Unit

- Patrick Tighe, Vice President

Services Business Unit - Bal Kakaria, Vice President

Projects Business Unit - Ken Petrunik, Vice President Nuclear Laboratories Business Unit

- Paul Fehrenbach, Vice President

ACR Business Unit.

- Ken Hedges, Vice President

The vice-presidents of the first three business units, Pat

Tighe, Bal Kakaria and Ken Petrunik, will report to Gary Kugler, Senior Vice President, Nuclear Products & Services.

The vice-presidents of the other two business units, Paul Fehrenbach and Ken Hedges, will report to David Torgerson, Senior Vice President, Technology.

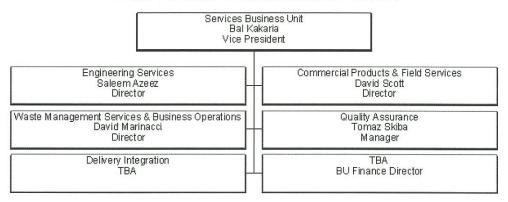
Each of these operations' vice-presidents will be a member of the Executive Management Committee. Collectively, they will continue to function as the Operations Management Team to manage the cross unit processes, issues and initiatives that will continue to be critical to the successful functioning of the new Business Units.

The organization of each of the business units is shown below.

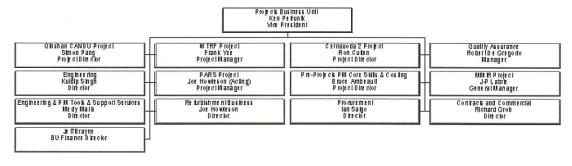
Customer Relations & Sales



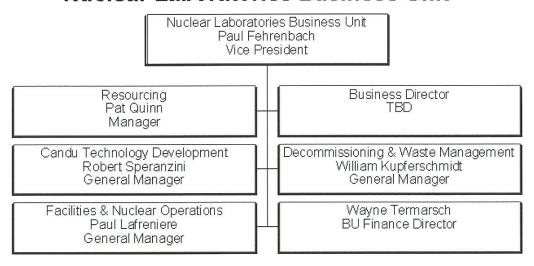
Services Business Unit



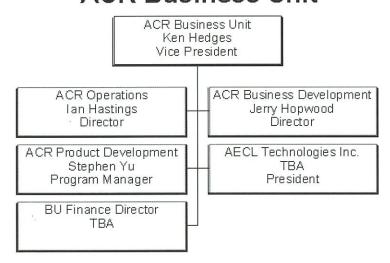
Projects Business Unit



Nuclear Laboratories Business Unit



ACR Business Unit



Diaz appointed chairman of USNRC

On April 1, 2003, US President George Bush designated Dr. Nils J. Diaz as Chairman of the Nuclear Regulatory Commission, succeeding Dr. Richard A. Meserve.

Dr. Diaz is in his second five-year term as an NRC Commissioner, having begun his first term on August 23, 1996. His current term runs until June 30, 2006.

In addition to the administrative responsibilities of the Chair, as a member of the Commission Dr. Diaz participates in the exercise and direction of the NRC's licensing and regulatory functions.

Dr. Diaz is Professor-Emeritus of Nuclear Engineering Sciences at the University of Florida. Prior to joining the NRC he was Director of the Innovative Nuclear Space Power Institute (INSPI)—a national consortium of industries, universities and national laboratories—and President and Principal Engineer of Florida Nuclear Associates, Inc.

His career includes 11 years as Director of INSPI for the Ballistic Missile Defense Organization of the US Department of Defense, two years in California as Associate Dean for Research at the California State University Long Beach, one year in Spain as Principal Advisor to Spain's Nuclear Regulatory Commission, and six years at nuclear utilities and vendors. From 1971-1996, Dr. Diaz consulted on nuclear engineering and energetics to private industry, the U.S. Government and several foreign governments.

Dr. Diaz holds a B.S. degree in Mechanical Engineering

from the University of Villanova, Havana, an M.S. in Nuclear Engineering and a Ph.D. in Nuclear Engineering Sciences from the University of Florida. He has received formal training and practice in Nuclear Medicine and Health Physics and was licensed as a Senior Reactor Operator for 12 years by the NRC. He has published more than 70 refereed papers on reactor kinetics and safety, instrumentation and control, imaging and non-destructive examination, advanced reactor concepts, nuclear space power and propulsion, and nuclear fuels. He is a Fellow of the American Nuclear Society, the American Society of Mechanical Engineers and the American Association for the Advancement of Science.

Contract for Second Cernavoda Unit

In mid April Atomic Energy of Canada Limited (AECL) announced that construction had begun on the second CANDU reactor at Cernavoda. Romania.

AECL, in partnership with ANSALDO of Italy and S.N. Nuclearelectrica of Romania, will manage construction of the 710MWe reactor, which will also include other suppliers from Canada, France and the United States.

The second Cernavoda reactor is scheduled to take fortyeight months to build at a cost US\$700M. At the peak of construction AECL will employ upwards of 120 people on site providing expertise in engineering, construction and commissioning supervision.

The first Cernavoda unit was completed in 1996. It produces about 10 per cent of Romania's electricity

CNSC authorizes start-up of Pickering 4

On Monday, May 5, 2003 the Canadian Nuclear Safety Commission announced that it had given permission to Ontario Power Generation to remove the "guaranteed shutdown state" (GSS) of Unit 4 of the Pickering generating station and begin commissioning towards start-up of the reactor.

With this regulatory hurdle passed OPG expects to have the unit back into commercial service by mid summer. The remaining three units of the Pickering A station are planned to be re-started over the next two years.

Back in February the CNSC granted a five-year operating licence to OPG's Darlington nuclear generating station. This was the first time a five-year licence has been granted to a Canadian nuclear generating station.

OPG to cease support of URL

In March, Ken Nash, vice-president of Waster Management of Ontario Power Generation, announced that, as of July 1, 2003, OPG will no longer be the sole source of funding for the base operation costs of the Underground Research Laboratory (URL) of Atomic Energy of Canada Limited located near the Whiteshell Laboratory in Manitoba.

He stated that OPG intends to prioritize its research and development activities related to waste management. Working relationships have been established with the Universities of Western Ontario, Waterloo, Laval, Toronto and New Brunswick and will be expanded to other Canadian universities, he said. Also, OPG has established information exchange agreements with SKB in Sweden and Posiva in Finland. Further international joint development programs will be established.

He stated that OPG intends to continue to resource work with AECL's Waste Technology Business Unit in the areas of geotechnical aspects of siting, repository engineering, and safety assessment codes.

Although URL contributed greatly to demonstrate the technical feasibility of a deep geologic repository, detailed design of such a repository will require site-specific information, he noted.

CNSC invites comment on waste policy

The Canadian Nuclear Safety Commission (CNSC) is inviting comment on its draft regulatory policy, P-290, Managing Radioactive Waste.

The proposed policy describes the principles that the CNSC will take into account when making regulatory decisions that concern the management of radioactive waste. It includes the CNSC's commitment to consult and cooperate with national and international agencies to promote consistent national and international standards for radioactive wastes.

The CNSC invites interested persons to assist in the further development of this draft regulatory document by commenting in writing on the document's content and potential by August 1, 2003.

All comments will be subject to the provisions of the federal Access to Information Act.

Draft Regulatory Policy P-290, Managing Radioactive Waste, can be viewed on the CNSC Web site < www.nuclearsafety.gc.ca >.

Qinshan 2 critical, ahead of schedule

The Qiinshan Unit 2 reactor reached first criticality on Tuesday, April 29, 2003, 52 days ahead of schedule.

A series of low power tests of the reactor's major components and operating systems were to be conducted over the following three weeks before the reactor's power levels are raised.

Unit 2 is the second of two 728 megawatt CANDU reactors on the Qinshan site located 125 kilometres southwest of Shanghai. Unit 1 has been in commercial operation since December 2002. That unit was built on budget and in 54 months (first pouring of concrete to full power), the shortest construction period of any nuclear plant in China.

New NB Power Nuclear granted licence

On January 31, 2003 the New Brunswick government tabled Bill 30, The Electricity Act in the New Brunswick

Legislature. The Act was passed and received Royal Assent on April 11, 2003. It is awaiting proclamation.

The Act provides for, among other things, the restructuring of New Brunswick Power Corporation (NB Power) into a holding corporation, New Brunswick Power Holding Corporation, with four wholly-owned subsidiary companies:

- New Brunswick Power Nuclear Corporation
- New Brunswick Power Generation Corporation
- New Brunswick Power Transmission Corporation
- New Brunswick Power Distribution and Customer Service Corporation

In anticipation of the Act coming into effect New Brunswick Power applied to the Canadian Nuclear Safety Commission to have the licences related to the Point Lepreau Generation Station transferred to the New Brunswick Power Nuclear Corporation.

On April 28, 2003 the CNSC announced its decision to issue operating licences to New Brunswick Power Nuclear Corporation to take effect when the Act is proclaimed and the company actually created. The new licences will have the same terms and conditions that exist in the current licences held by New Brunswick Power Corporation. The expiry dates for the licences remain July 31, 2003 for the Point Lepreau Solid Radioactive Waste Management Facility and December 31, 2005 for the Point Lepreau Nuclear Generating Station.

Obituary

William McKenzie Gilchrist

Another early leader of the Canadian nuclear program has passed away. William (Bill) Gilchrist, long time president of Eldorado Mining and Refining and a member of the Atomic Energy Control Board (predecessor to the Canadian Nuclear Safety Commission), died March 22, 2003 in Ottawa at the age of 93.

Bill Gilchrist was born in Saskatchewan in 1909. He attended University of Manitoba and Queen's University, graduating in mining engineering in 1936. From then to 1941 he worked for Preston East Dome Mines and then spent four years with the Royal Canadian Engineers, 1941 to 1945, during the Second World War. He joined Eldorado in 1951 as assistant manager of the Beaverlodge mine in northern Saskatchewan. In 1958 he was appointed vice-president of Western Operations and later that year as president of Eldorado Mining and Refining, a post he held until his retirement in 1974. He was also president of Eldorado subsidiaries, Eldorado Aviation and Northern Transportation.

(Eldorado Mining and Refining changed its name to

Eldorado Nuclear in 1968 and on 1988 merged with Saskatchewan Mining Development Corporation to form Cameco Corporation.)

As president of Eldorado, Gilchrist was a member of the Atomic Energy Control Board. Those were the days when the heads of Eldorado and Atomic Energy of Canada Limited were on the AEC Board along with the president of the National Research Council. Despite the apparent conflict of interest he was always impartial in his role on the AECB.

Gilchrist was a member of the Board of the Canadian Nuclear Association from the early 1960s until 1978 and president (chairman) in 1971 - 72. He was president of the Canadian Institute of Mining and Metallurgy in 1974 -75. Having a passion for Canada's north he was a Governor of the Arctic Institute of North America and was involved in the renewal of the "Beaver" history journal. In recognition of his contributions he was awarded the Massey Medal of the Royal Canadian Geographical Society for his "outstanding contributions to the development of Canada's north".

CNS news

Annual General Meeting

The Annual General Meeting of the Canadian Nuclear Society / Société Nucléaire Canadienne, Inc. will be held Monday, June 9, 2003 in the Grand Ballroom, Salon D, at the Marriott Eaton Centre Hotel in Toronto, beginning at 5: 00 p.m. This is the sixth AGM of the society since its incorporation. The meeting will be at the end of the first day of the 24th CNS Annual Conference and the embedded 28th CNS/CAN Student Conference. (It is not necessary to be

registered for the conference to attend the AGM.)

Members were sent notices by mail along with a proxy form. Any member wishing to vote by proxy but missing the form should contact the CNS secretary, Ben Rouben (tel. 905-823-9060 x 4550 e-mail: roubenb@aecl.ca)

A slate of nominations for officers and members of the CNS Council has been presented. Further nominations from the floor at the AGM will be accepted.

BRANCH ACTIVITIES

Bruce Eric Williams

The following presentations are now planned:

Wednesday 18 June 2003 – **Dr. David Torgerson**, AECL, "Advanced CANDU Reactor".

Wednesday 2 July 2003 – **Dr. Murray Stewart**, ITER Canada, "ITER, the Project and Project Status".

Date To Be Determined – **Ms Elizabeth Dowdeswell,** President, Nuclear Waste Management Organization, "Bill C-27".

During the last month four copies of "Unlocking The Atom", by Hans Tammemagi and David Jackson, were presented to the Bruce County Libraries (Kincardine, Tiverton, Port Elgin) by the Bruce Branch of the CNS. The book was not previously available through the Library system.

Chalk River Michael Stephens

Upcoming talks by **Elizabeth Dowdeswell** (NWMO), a representative from the IMO, and **Peter Boczar** (AECL) have been planned, but no dates set.

The branch was instrumental in saving a number of historical and PR items from uncertain fate as the AECL-CRL Visitors Centre liquidated its contents (CRL does not take visitors anymore). About \$500 was spent to transport the items to Deep River and place in long-term storage. This includes 500-600 copies of "Canada Enters the Nuclear Age" discussed in the ECC report.

Manitoba Jason Martino

Jason reports that there has been no Branch activity. However, he submits the following comment.

The Waste Technology Business Unit, which contains most of the Manitoba branch's members is in the process of being closed. With less than three years to go until the Nuclear Waste Management Organization makes its recommendation to the Federal Government on the way forward for dealing with used nuclear fuel in the long term, the people developing the technology are being laid off. This includes the impending closure of the Underground Research Laboratory in Manitoba were there are full scale experiments ongoing, one of which the Tunnel Sealing Experiment is funded Internationally by the Japan Nuclear Cycle Institute and ANDRA. These experiment will likely be terminated before they are complete.

In a time when potential reactor sales are on the near horizon, a hugely shortsighted choice is being made not to deal with issues surround the used fuel from those reactors. I would urge all CNS members to write Herb Dhaliwal, their MPs and AECL about this choice.

Ottawa Bob Dixon

The Ottawa branch held its last meeting of the winter season on April 24. The speaker was **Paul Fehrenbach**, V.P. Nuclear Laboratories Business Unit, who spoke on the topic "CANDU R&D: Now and in the Future". The presentation concluded a successful winter program with excellent support from branch members.

Québec Michel Rhéaume

The Branch proposes to support a student's reactor simulation project at Ecole Polytechnique under Prof. Elizabeth Varin.

Toronto Andrew Lee

The Toronto Branch is regrouping. Andrew Lee takes up the Branch chair's post. The branch is planning to have three to four seminars this year. The audiences are aimed at the University of Toronto students and OPG staff. Detailed dates and locations are still on the draft board. The potential speakers include **Dr. Torgerson**, **Dr. Bereznai** and others.

As a postscript, Adam McLean, former energetic chairman of the Toronto Branch, sends this note from San Diego where he is pursuing doctorate studies.

The San Diego branch of the CNS - membership 1 - is doing very well. Overall, it's member(s) are working far too many late nights in the DIII-D fusion reactor 'pit' - learning diagnostics, heating systems, magnetic instabilities, spectroscopy, actually experiencing 'dirty hands' instead of programmers carpal tunnel syndrome, but fortunately loving every minute of it:)

Two weekends ago the branch took part as a judge in the San Diego County Science and Technology fair on behalf of General Atomics and the University of Toronto. It was a wonderful event - even bigger than our annual final fair in Toronto with a very comparable level of achievement. It's always great to see so many students actually excited about science!

In a cross-society experience, the San Diego branch of the CNS was in attendance at the latest ANS San Diego section event - a dinner meeting and presentation by Edward "Ted" Quinn, a former ANS president, on Advanced Reactors and the Future of Nuclear Energy. The CNS was very excited to be part of the event and anxiously offered the latest developments in the ACR program, discussing it's improvements over previous systems, and much to the joy of the predominantly American audience, the shedding of our well known "positive void" feature:)

The San Diego branch looks forward to meeting the CNS delegation attending the ANS summer meeting in June.

Support the Nuclear Waste Management Organization

From: Duane Pendergast

Duane Pendergast, formerly with AECL, has his own consulting company Computare. He is co-chair of the Environment and Waste Management Division of the Canadian Nuclear Society

Elizabeth Dowdeswell, president of the Nuclear Waste Management Organization (NWMO), spoke to the Canadian Nuclear Association (CNA) Winter Seminar on March 19, 2003. The goal of the organization is to come up with recommendations for long-term management of nuclear wastes by November 15, 2005. (Her presentation is available on the CNA website under the Nuclear Industry Seminar heading.)

She outlined the process and indicated that their website (http://www.nwmo.ca) would form the core of public consultation. The NWMO's first annual report was issued in March after only three months activity. It usefully supplements Ms. Dowdeswell's presentation to the CNA and is available on their website.

I've quite a bit of experience providing input to these Internet based public forums now thanks to my involvement in climate change issues. The federal government did pay considerable attention to the submissions on the federal climate change stakeholder workshops. In particular the plan issued before Christmas bent over backwards to accommodate the objections of various interest groups and the results of public polls. The plan was not quite so quick to adopt some of the more useful and positive contributions from the nuclear industry. However it is far too soon to tell how much our input will be appreci-

ated. Thus far the plan is most preliminary and unlikely to meet the Kyoto goal. At least the capability of the nuclear industry to contribute to lowered emissions is well and publicly covered in the body of knowledge put together by the National Climate Change Process.

I've reviewed the NWMO website. Preliminary discussions with stakeholders and selected members of the public have already been undertaken. The results were reported on the NWMO website as of January 15. Public interest is said to be very low key and knowledge of the issues was deemed to be extremely limited. The report suggests many points that will require clarification and/or correction as the process continues.

The website invites additional public comment via the "Contact Us" web page. Input is solicited via a form that allows for the provision of a single attached document. At the time of my review it was not clear just what will be done with the information. Certainly the form is set up so that input could be accumulated in a neat web server computer generated report. The ultimate intent may be to edit that and make the information public as well as to undertake some analysis of any useful information and assess submitted opinions.

I submitted a one page "message" via the website. It builds on the idea, already expressed by the limited meetings undertaken with stakeholders, that used nuclear fuel might be recycled and reused. The main point I make is that the used fuel constitutes an important energy resource that should be preserved in view of limited fossil fuel supplies and the climate change issue. I provided some references and attached one article that I think might be useful in this context. At this

point the feedback from NWMO is very encouraging. Within three days of my submission I received two or three computer generated notes of thanks and two personal emails from a staff member. The first thanked me and indicated my message had been circulated to colleagues. The second advised me they would soon have a "Submissions" function in place. Submissions will be publicly posted on the NWMO website and my input was judged to fall in that category. I was asked to resend when the Submissions function is available. I'll do that. I expect it will be available before this is published.

On behalf of the Environment and Waste Management Division, I urge others to provide the NWMO with basic information that will help the public - and the NWMO - put this issue in perspective. The form is straightforward and easy to use. It seems the NWMO has been overwhelmed with input yet.

I learned, during my involvement with climate change that the perception there is no way to deal with nuclear waste is the most deep-seated barrier to more widespread public acceptance of nuclear electricity. The information already on the NWMO website provides many clues to the lack of understanding. This is our chance to learn from our potential public supporters, to be heard, and to contribute factual information that will allow understanding to develop.



ANS to present award for NPD

At its winter meeting in November 2002, the American Nuclear Society announced that it was going to grant an "ANS Nuclear Historic Landmark Award" to NPD.

The actual presentation of this award will be by incoming ANS president, Larry Foulke, at the luncheon on Monday, June 8, 2003, during the CNS Annual Conference in Toronto.

Mr. Foulke will also be giving a talk on "The Status and Future of Nuclear Power in the USA"

2004 International Youth Nuclear Congress

Toronto, Ontario, Canada May 9-13, 2004. Call for Papers

The 2004 IYN Congress will be held at the Courtyard Marriott in downtown Toronto, Ontario, Canada May 9-13, 2004.

The theme of IYNC 2004, 'A World of Innovations', reflects the viewpoint of the new generation of nuclear professionals, and recognizes the many novel techniques that have been developed throughout the history of nuclear science and technology that both retain and extend the nuclear option for present and future generations. These innovations encompass all aspects of nuclear technology - from energy generation and industrial processes to medical applications and space travel. In addition to panel sessions and workshops, the Congress will include oral and poster presentations in the following topical areas as they relate to nuclear science and technology:

- · Social and Policy Issues
- Nuclear Fuel Cycle
- Non-Power Applications of Nuclear
- · Environmental and Waste Management

Participants are invited to submit summaries for presentation at the Congress by September 30, 2003,

For further details about the Congress go to the IYNC website < http://www.iync.org > or e-mail to < submit@iync.org >



24th Annual Canadian Nuclear Society Conference and 28th Annual CNS/CNA Student Conference



2003 June 8-11, Marriott Eaton Centre, Toronto, ON <u>Preliminary</u> Program as of 2003 May 07

Sunday June 8, 19:00-21:00 Conference Reception

Monday	June 9	14:20	Safety Culture, L.J. Keen (CNSC)
	I Overseas and Domestic Opportunities	14:45	Break
08:30	Welcome, J.E. Wilson (CNS President) and K. Routledge (NSS, Conference Chair)	15:15	Opportunities for CANDU for the Alberta Tar Sands, J. Hopwood (AECL)
08:45	Progress at Qinshan and Future Prospects in China, K. Petrunik (AECL)	15:40	The Evolution of the Uranium Market, J.R. Britt (Cameco Inc.)
09:10	Value-Added Services to CANDU Plants, <i>B. Kakaria</i> (AECL)	16:05	Supply of Isotopes for the World's Medical Community, plus Update on Maple Reactors, <i>G. Malkoske (Nordion)</i>
09:35	Additional Nuclear Capacity for Finland, A. Toivola (TVO, Finland)	16:30	Brief Updates on Topical Issues: - Fusion & ITER Project – The Opportunity for Canada, <i>M.</i>
10:00	Break		Stewart (Iter Canada)
10:30	Presentations on New Reactor Designs:		- Union Developments, D. MacKinnon (PWU)
	- AECL's ACR (D. Torgerson, AECL),	18:00	Reception: Cocktails and Music
	- Westinghouse's AP 1000 (S.J. Walls, BNFL),	18:50	Nuclear Achievement Awards Banquet
	- Framatome's EPR (G. Hudson, Framatome		+ More Music & Entertainment
	ANP), and	Wedne	sday June 11
	- GE'S ABWR & ESBWR (A. Rao, GENE)	Plenary	III: Utility Reports & Future Expectations
11:30	Panel Discussion on Potential Markets for Advanced Reactor Designs	08:25	OPG Nuclear Performance – Status & Outlook, P.R. Charlebois (OPG)
12:00	12:00 Luncheon - Presentation of ANS Nuclear Historic Landmark Award to NPD by Larry Foulke, President,	08:55	Bruce Power - The First 24 Exciting Months, R. Mottram (Bruce Power)
	American Nuclear Society, followed by his invited talk "The Status and Future of Nuclear Power in the U.S."	09:25	New Brunswick Power Business and Operations Update, <i>R. White (NB Power)</i>
14:00	Parallel Technical Sessions: • Student Session I	09:45	Possible Refurbishment of Pt. Lepreau, R. Eagles (NB Power)
	• The Future • Safety I	10:05	Break
	 Control Room / Operations I Physics 	10:30	Gentilly-2 Performance and Future Refurbishment,
17:00	CNS Annual General Meeting		M. Doyon (Hydro-Québec)
	(Open to all CNS members; Review of CNS Year + Election of CNS Council for 2003-04)	10:50	Pakistan's Civilian Nuclear Program, W.M. Butt (PAEC)
Tuesda;	y June 10	11:10	Panel Discussion on Open Electricity Market, Decontrol,
08:30	Parallel Technical Sessions:		and Privatization,
	Student Session II		A. Johnson (Bruce Power),
	Life Extension • Probabilistic Safety		B. Campbell (IMO), B. Boland (OPG),
	Assessment • Control Room/Operations II	40.00	Chair of Panel: K. Talbot (Bruce Power)
	• Reactors & Components I	12:00	Luncheon - Presentation of the CNA International
	Thermalhydraulics & Radiation		Award, followed by luncheon address by the recipient (Name withheld)
10:00	Canadian Nuclear Association AGM	14:00	Parallel Technical Sessions:
10:30	CNA Board meeting (Board members only)	14:00	Student Session III
12:00	Young Generation in Nuclear – Professional Development Seminar 2003		Advanced CANDU Reactor
Plenary	II Current Issues and Future Developments		• Safety II
13:30	Recent Developments and Future Plans re Nuclear Waste Management in Canada, <i>E. Dowdeswell (NWMO)</i>		Control Room / Operations III Reactors and Components II
13:55	What's Happening at the Canadian Nuclear Association (CNA): Current Priorities,		End of Conference – See you in 2004!

CNS Bulletin, Vol. 24, No. 2



Canadian Nuclear Society 24th Annual Conference (incorporating Student Conference) Toronto, Ontario 2003 June 8-11

REGISTRATION FORM

(Please	type or v	write in block letters)	
Name:			
(Dr./Mr./Ms.) Title:		Last	
Organization:			
Business Address: _	Street #	Street Name	
	Jucet #		
City		Province/State	
Postal Code		Country	
Business Telephone	:		
Fax:			
E-mail:			
If you are a speaker	, please	check this box:	
If a speaker at the §	student (Conference, pls. check □	
If you would like ve	getarian	meals, pls. check this box:	
This registration for at www.cns-snc.ca.	rm is als	o available on the CNS web site,	
to Canadian Nuclea Suite 200, Toronto,	r Societ ON, M	registration form with payment y, 480 University Ave., 5G 1V2 cns-snc@on.aibn.com	
	e Roube	garding the Conference, please n, CNS Office Manager, using ove.	
The Conference Hotel will be the Toronto Marriott Eaton Centre, 525 Bay St., Toronto, ON, M5G 2L2. Room reservations must be made <u>directly</u> with the Hotel at 1-800-905-0667. When calling the hotel, you must indicate that the reservation is for the CNS 2003 Annual Conference. A block of rooms is held for the Conference until 2003 May 18; please reserve early. The price of rooms is \$199 per night + tax, single or double. Smoking or non-smoking rooms are available upon request.			
For Office Use:			
CNS Member? Yes ID #: Entered: 2003/ Processed: 2003/ Receipt sent: 2003/	□ No	-	

REGISTI	RATION OPTIO	NS
Registering:		After May 12
CNS Member	\$530.00 □	\$600.00 □
Non-CNS Member	\$595.00 □	\$665.00 □
(Includes all CNS Sessions	s, one copy of Procee	edings, Reception,
Conference meals includin	g Banquet)	00000000
CNS Retiree Member	\$160.00 □	\$200.00 □
Full-Time Student		\$130.00 □
(Includes all CNS Sessions		edings, Reception,
Conference meals includin		
Note: Registration fee is w at the <u>Student</u> Conference		resenting a paper
One-Day Registration (I	ncludes sessions ar	nd Conference
meals for the day - Lune		
on Tues. Does not inclu		
Please indicate for which		5)
CNS Member		\$310.00
Non-CNS Member	\$310.00 🗆	\$340.00 □
Guest accompanying reg (Permits compli Guest's Name:	mentary attendan	ce at Reception)
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 Visitors to Cana 		\$
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Signature (required for o	eard payment):	
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Please note Cancellation Policy: A fee of \$100 will be charged for all cancellations received after 2003 May 12.

New members / Nouveau membres

We would like to welcome the following new members, who have joined the CNS recently.

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

Radik Rinatovich Ixanov Yanfei Rao, AECL

Philip G. Smith

Brian D. MacTavish, CANDU Owners' Group Inc.

Catherine M. Cottrell, AECL Loc Tien Nguyen, AECL Elizabeth Zariffeh, AECL Elias Zariffeh, AECL

Robert Stevens, New Brunswick Power Jana Ene Parent, Hydro-Québec Haihui (Stella) Yang, Ryerson University Osmani Oberd Fernandez Batista

Adriaan Buijs, AECL

Colette Tremblay, Université Laval Deonaraine Ranjit Singh, AECL Susan Mari Yatabe, AECL Beom Su Lee, AECL Michel Saint-Denis, AECL

Michael R. Specht, Bruce Power
Thuy Nguyen Nguyen, Poyal Military College

Thuy Nguyen Nguyen, Royal Military College of Canada Lucia Elena Bordas Golan, AECL

Parisa Sarah Sabouri Cuong Ngo-Trong, AECL

Anca Iolanda Popescu, RCM Technologies Canada Corp.

Gayatri Badrinath, AECL

Jamie Higgs, Royal Military College of Canada Lee Rehorn, University of Wetern Ontario Dragan Komljenovic, Hydro-Québec Larry Blake, Nuclear Safety Solutions Ltd. Curtis E. Jurgens, Day & Zimmermann NPS, Inc. Brant A. Ulsh, McMaster University Douglas R. Boreham, McMaster University Marsha I. Sheppard, ECOMatters Inc.

Nicolae Anghelidis, AECL

Brian C. Hartz, Day & Zimmermann NPS Charles Mummert, Day & Zimmermann NPS

Tayeb Houasnia, Hydro-Québec

Emil Iancu, PNGS-A Ricky Khaloo, AECL Milan Gacesa

Charles Doucet, New Brunswick Power

Robert Mallozzi, AECL

Melissa Zariffeh, St. Ignatius of Loyola Catholic

Secondary School Larry Fred Austin

Steven Thoss, Ontario Power Generation

Hartmut Ted Westermann

John Knox Sutherland, Edutech Enterprises Holly M.E. Tremain, McMaster University David Shoesmith, University of Western Ontario

Li Yan, University of Western Ontario

John A. Honey, Nuclear Insurance Association of Canada Amy Cosy Lloyd, University of Western Ontario Jon Scott Goldik, University of Western Ontario

Bill Santos, University of Western Ontario Charmaine Lee, University of Western Ontario

Amy Fluke, Stern Laboratories Inc. Abdul-Samed Seidu, Royal Military College Xihua He, University of Western Ontario Omar Jamal Shaikh, McMaster University Syamak Ghorashi, Ultimate Project Management Inc.

Leon Fitzroy Simeon, RCM Technologies

Barbara Szpunar, AECL Negin Ghalavand, AECL

Joo Hyun Kim, Korea Electronic Information Center Kathy Creber, Royal Military College of Canada Jared Smith, University of Western Ontario

Ginni Kaur Cheema, AECL

Marc Desormeaux, Royal Military College

Violeta Sibana, AECL

Imtiaz Baig

Donald (D) "Marc" Kealey, AECL

Keith MacDougall, SRB Technologies (Canada) Inc. Magdalena Papuse, SNN-SA CNE-PROD Cernavoda NPP

Raphaël Schirrer, Hydro-Québec

Daniela Velcheva Aldeva Stephen R. Emery, Emery Consulting Inc.

Mau Vuong, Graduate Student Cvetan Kostadinov Aldev

Derek R. Lane-Smith, Durridge Company Inc.

Dharapuram P. Murugesan, AECL

Kumud Deka, University of New Brunswick

Sandy Ross Donald, Bruce Power

James J. Noël, University of Western Ontario

Tammy Chin, AECL James Lévêque

Walter Tomkiewicz, North American Power Partners Yongbo (Steven) Zhu, University of Ottawa

Keep us informed

Dear CNS member: Help Us Keep the CNS Membership Database Up to Date

If any of your personal information (e.g., employer, title, address, phone number, e-mail address, etc...) has changed recently or will soon change, please send the correct information to the CNS office (numbers below) so that we may keep the membership database in good order. Thank you!

Cher/Chère membre de la SNC : Veuillez nous aider à garder la banque de données des adhésions à jour

Si tout détail personnel (par exemple employeur, titre, numéro de téléphone, adresse électronique, etc...) a changé récemment ou changera très bientôt, veuillez le communiquer au bureau de la SNC (numéros ci-bas), afin que la banque de données soit toujours correcte.

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FAX/Télécopieur : 416-977-8131 E-mail/Courriel : cns-snc@on.aibn.com



From the Nuclear Waste Management Organization

From Dialogue to Decision

This is the title of the first Annual Report of the Nuclear Waste Management Organization, which actually covers just three months from the creation of NWMO on October 1, 2002 to the end of its fiscal year, December 31.

Nevertheless, it gives an interesting account of the beginnings of the organization and its initial round of consultations. Perhaps more interesting is the outline of the planned next phases leading up to a report to the Minister of Natural Resources at the end of its three year mandate.

It is available on the NWMO website < www.nwmo.ca > or by writing to Nuclear Waste Management Organization, 49 Jackes Avenue, 1st floor, Toronto, Ontario M4T 1E2 Or by calling 416-934-9814 or (toll free) 1-866.249.6966

Report on Discussion Group findings

Almost as soon as it was formed in the fall of 2002 the NWMO engaged a public opinion research company, Navigator Limited, to conduct a series of 14 exploratory discussion groups to obtain some indication of the public's view about long-term nuclear waste management. As might be expected, they found that the knowledge of nuclear waste or nuclear power was "extremely low".

This 20 page report is available on the NWMO website or from the address above.

From the OECD Nuclear Energy Agency

Establishing and Communicating Confidence in the Safety of Deep Geologic Disposal

This 180 page report is the result of the efforts of a Working Group originally set up in 1994. It brings together arguments made primarily related to "integrated performance assessments" for geologic disposal facilities in different countries.

Ed. Comment: The material presented is very technical. While the arguments presented may have convinced regulators they would be useless as a communication to the public.

This report is available from: OEDC, 2, rue André-Pascal, 75775 Paris Cedex 16, France

The Regulatory Challenges of Decommissioning Nuclear Reactors ISBN 92-64-02120-5. 32 pages (154 kb).

This relatively brief report outlines what operators and the regulator should do when a facility enters the decommissioning phase. Both should expect a heightened public interest and concern, which must be addressed.

It is available on the NEA website: < www.nea.fr/html/pub/webpubs > or paper copies may be requested by sending an e-mail to nea@nea.fr.

From Industry Canada

Canadian Fuel Cell Commercialization Roadmap

To quote from the Executive Summary: "The Canadian Fuel Cell commercialization Roadmap is an industry-led planning process ... facilitated by Industry Canada. Its objective is to accelerate full-scale commercialization of fuel cell technologies."

The report summarizes fuel cell technology, the Canadian fuel cell industry. There is just a two paragraph note on the source of hydrogen needed for the fuel cells and a passing reference to the fact that thee are no greenhouse gas emissions if hydrogen is produced by electrolysis using electricity from hydro, wind geothermal and (surprisingly) nuclear.

The publication is free and available from Industry Canada, tel: 613-947-7466. e-mail: < publications@ic.gc.ca >

From Canadian Nuclear Association

The Value of Nuclear Power to Canada's CO2 Emissions Trading System

Despite the ponderous title this attractive brochure contains considerable information on CO2 emissions from different components of the electricity generating sector.

To obtain a copy contact: Colin Hunt, CNA, e-mail: huntc@cna.ca.

From the Canadian Nuclear Safety Commission

To obtain copies of CNSC documents contact: Canadian Nuclear Safety Commission, P.O. Box 1046, Station B, Ottawa, Ontario, K1P 5S9 Or e-mail: publications@cnsc-ccsn.gc.ca

Regulatory Guide G-274

Security Programs for Category I or II Nuclear Material or Certain Nuclear Facilities

The purpose of this guide is to provide information on the preparation of security information required under the Nuclear Safety and Control Act.

Leaving The Barn Door Open

by Jeremy Whitlock

Our nuclear conferences are rather monochromatic affairs, as most corporate gatherings tend to be. Plenary sessions offer vistas of grey pin-stripe and matching hair. Sombre intonations resonate about past successes, current concerns, future strategies - all with a dour stoicism befitting a Very Serious Business.

Here and there a refreshing glimpse of colour, like the girl in the pink dress in "Schindler's List", indicates the rare presence of a female attendee. The eye is drawn to the novelty. The mind appreciates the creative respite.

There is much to be colourful about in our industry. We desperately

need novelty, creativity, fresh approaches - in short, spunk. We are, every war-weary one of us, the custodians of one of the most important inventions of Mankind, and apparently one of the most misunderstood.

Let us do as W.B. Lewis exhorted, at the pinnacle of his elder statesman status, and fight a bad meme with a good meme, for never in the history of this planet has a technology generated as much energy with as little impact on the environment.

And all despite the technology being yet in its infancy. This "Mozart phenomenon" is no quirk, but a classic signature of revolutionary discovery. Another is having no limitations in sight, save self-destruction.

We need to talk to people, not just bureaucrats and politicians. We need to talk to a lot of people, everywhere, all at once and in small groups. We need to engage the beautifully objective and imaginative minds of youth. We need to earn the trust of the caring and concerned.

No clearer a wake-up call is required after Ontario's electricity overseer, the IMO (Independent Electricity Market Operator, www.theIMO.com), released its latest long-term outlook in March. It appears that Canada's industrial heartland needs some 15,000 new megawatts in the next 15 years, including replacement/refurbishment of almost half the province's aging supply.

Unfortunately, the first decade of that forecast looks pretty good for supply; the bottom drops out in the subsequent five years. This is fortunate for the air-conditioners, but very unfortunate for the planners who have already spent 15 years hamstrung by political interference.

It's a classic problem: how do you convince the public to build infrastructure for a 10-year horizon? Ontario Hydro tried to do it in the late-80s and got side-swiped by a recession, with Energy Probe leading the cry of repugnance

(TBANG: Too Big and Not Natural Gas). Some of those projects would be coming on-line about now, and instead a few are being reconsidered in 2003.

The IMO wants reliability, and logically suggests more nuclear power. The federal government wants image, and logically pretends nuclear power doesn't exist. Its bright idea for meeting Kyoto targets turns out to be getting Canadians to use less electricity.

Fat chance.

But who cares when you've got (seemingly) 10 years' breathing room? That's another politician's career.

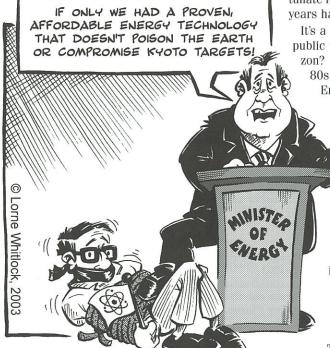
In the U.K. a similar fool's paradise has the Blair government vowing to reduce CO2 production by 60% from 1990 levels over the next half-century, while replacing nuclear power's 20% share of national electricity production with renewables.

Or at least that's the war cry for the next five years, at which time they'll have another look at the situation. This "leave the door open" cop-out is the biggest tribute to political ephemerality since an NPD government went berserk in Ontario and short-circuited its electrical utility.

Which brings us to nuclear waste management: our finest example of a necessary technology with too much breathing room. Decades of research, millions of dollars, years of public review, the most appropriate geology in the world - and merrily we punt the topic from immediate view. While our new Nuclear Waste Management Organisation (NWMO) gives three years' sober second thought to the whole affair, we shut down our Underground Research Lab and bleed away the expertise.

So what's really needed is a Nuclear Waste Creation Organisation. Its three-year mission: to boldly go where no federal government has gone before. Have it out with the public, coast to coast. Lay out the needs, the options, the true costs. Answer all questions mercilessly. Consider all roads forward. Suffer only the facts. No havering, wavering, or favouring. The mandate at the end of the day: how we are really going to make electricity in this country for the next 50 years.

Sounds a bit colourful, perhaps, but there you go.



CALENDAR____

2003		Oct. 13 - 14	PLIM & PLIX Conference New Orleans, LA, USA
May 25 - 29	CRPA / ACRP 2003 CanadianRadiation Protection Association Kananaskis, Alberta Contact: Patrick harder email: pharder@ucalgary.ca	Nov. 9 - 13	Contact: Julie Rossiter Wilmington Publishing Ltd. e-mail: jrossiter@wilmington.co.uk website: www.plimplex.com ANS/ENS International Winter Meeting
June I - 5	ANS Annual Meeting San Diego, California e-mail: meetings@ans.org web: www.ans.org		New Orleans, LA, USA Contact: American Nuclear Society e-mail: meetings@ans.org website: www.ans.org
June 8 - II	24th CNS Annual Conference and 28th CNS / CNA Student Conference Toronto, Ontario Contact: CNS Office Tel: 416-977-7620 e-mail: cns-snc@on.aibn.com	Nov. 16 - 18	6th International CANDU Maintenance Conference Toronto, Ontario Contact: CNS Office Tel: 416-977-7620 e-mail: cns-snc@on.aibn.com
July 6 - 10	Plutonium Futures – the Science 2003 Albuquerque, New Mexico e-mail: puconf2003@lanl.gov website: www.lanl.gov/pu2003	2004 Mar. 21 - 25	PBNC 14 14th Pacific Basin Nuclear Conference Honolulu, Hawaii
Sept. 15 - 19	International Conference on Advanced Nuclear Power Plants and Global Environment Kyoto, Japan Contact: Atomic Energy Society of Japan American Nuclear Society website: genes4-anp@nuclear.jp	Apr. 25 - 29	Physor 2004 Chicago, Illinois Contact: Ray Klann Argonne National Laboratory e-mail: klann@anl.gov
Sept. 22 - 24	International Conference on Supercomputing in Nuclear Applications Paris, France e-mail: SNA2003@cea.fr website: www.SNA-23.cea.fr	May 9 - 13	IYNC3 3rd International Youth Nuclear Congress Toronto, Ontario Contact: Adam McLean e-mail: adam.mclean@utoronto.ca
Sept. 22 - 24	8th International CANDU Fuel Conference Delawana Inn, Muskoka Ontario Contact: Brock Sanderson AECL - CRL Tel: 613-584-8811 x3368 e-mail: sandersonb@aecl.ca	June 6 - 9	25th CNS Annual Conference & 29th CNS/CNA Student Conference Toronto, Ontario Contact: Denise Reuben Canadian Nuclear Society Tel: 416-977-7620 e-mail: cns-snc@on.aibn.com
Oct. 5 - 8	Advances in Nuclear Fuel Management III Hilton Head Island, South Carolina, USA Contact: Bojan Petrovic email: petrov@Westinghouse.com	June 13 - 17	ANS Annual Meeting Pittsburgh, Pennsylvania Contact: American Nuclear Society website: www.ans.org
Oct. 5 - 9	NURETH-10 10th International Topical Meeting on Nuclear Reactor Thermal Hydraulics Seoul, Korea Contact: Soon-Heung Chang e-mail: nureth10@mail.kaist.ac.kr		

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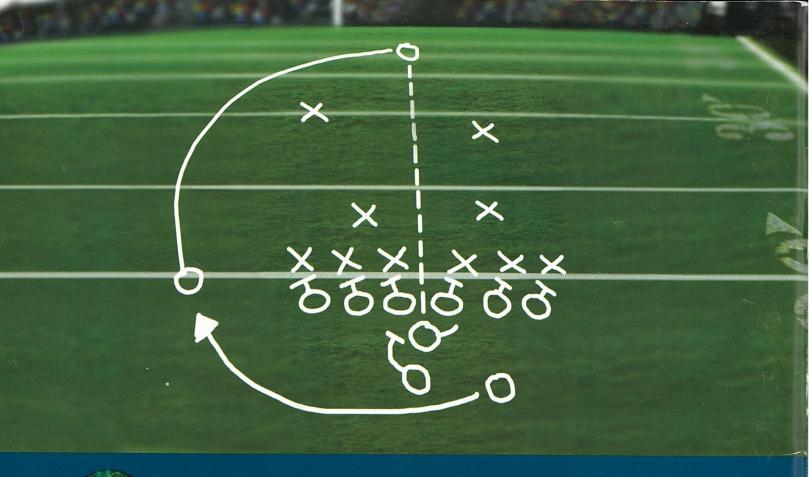
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For information on CNS activities and other links http://www.cns-snc.ca





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