CANADIAN NUCLEAR SOCIETY

bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

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EDITORIAL

Dichotomies, Dilemmas, Directions

As usual, the annual CNA/CNS Winter Seminar in February revealed much of the state of the nuclear program in the Canada, with all of its current dichotomies, the seemingly ever present dilemmas, and several proposals for the directions to follow.

The dichotomies lie in all of the major components; the nuclear power program, the radioisotope business, and the realm of research and development. Again, we were told that the domestic prospects for nuclear power are essentially nil, but, the project in China was going well and there are great prospects elsewhere. Canada is still the leading supplier of radioisotopes, for medical, industrial and research uses, but, other suppliers are emerging, and, Health Canada is still procrastinating on the approval of food irradiation. A new nuclear research facility, to replace the ageing NRU reactor, is desperately needed, the research community supports it and federal politicians say nice words, but, no money is forthcoming.

Faced with these situations, speaker after speaker reflected on the basic questions, where should we go, what direction should we take?

For the nuclear power game, there appears to be no other option than to continue to strive for overseas sales, while restoring our domestic units. Efforts are being made in Turkey (again), and for continued business in China and Korea where, fortunately, Canada has a good nuclear reputation. The supply of radioisotopes will be ensured when the two Maple reactors currently under construction at Chalk River are completed later this year and next, and new radiopharmaceuticals are being developed. There is even hope that continued movement in the USA on food irradiation may eventually shake the officials and politicians at Health Canada out of their intransigence and lead them to approve this very beneficial process. However, on the research front, AECL and NRC appear to have a major selling job on their hands if they are to convince the federal government to provide most of the funds needed for the proposed Canadian Neutron Facility. If they do not succeed this could be the "Achilles Heal" of our nuclear program for such a facility is absolutely needed to support the power program as well as to maintain our level of scientific competency.

Finally, as delegates were reminded again, there remains the problem of negative public perception. If the industry does not take action on this problem whatever successes are made in other areas will disappear.

F. B.

IN THIS ISSUE

There are a few layout changes in this issue of the *CNS Bulletin.* Because of the advertisement on the inside front cover the "Contents" list and masthead have been moved to page 3.

Another missile from Archie Robertson, **To Air is to Err,** this time pointed at the CBC, is presented as a "Viewpoint". Those who enjoyed his two-part critique of the Seaborn panel report in "Malice in Blunderland" will appreciate his thrust at our national radio and TV network. Another opinion on another subject is presented in a relatively long letter on the on-going topic of **LNT.**

We present a quick look at one of the smaller but key components of the Canadian nuclear industry in, **Nu-Tech - maker of CANDU pressure tubes,** which we hope you will find interesting as well as informative.

The major technical paper is longer than normal. However, the topic covered in **Hydrogen and Nuclear Energy** is topical and important. Hydrogen is being touted as the miracle, non-polluting, fuel for transportation, but little is said about its source. This paper provides a detailed analysis of the potential synergy of nuclear and hydrogen.

A review of the approach taken at Point Lepreau to regain its once high standing in world performance records is presented in the paper **Improving Performance in a Competitive Environment.** This is followed by a relatively technical paper on a specific aspect of the design of a CANDU nuclear power unit which has great importance, **Redesigned SG Divider Plate Withstands LOCA.** There is a report on the **Hearings on Electricity in New Brunswick** and a short paper on a topical issue, **Safety Culture - a view from the IAEA.**

There are reports on two quite different meetings: the **CNA/CNS Winter Seminar,** that annual gathering of senior industry and government representatives to review the status of the Canadian nuclear program; and the **CNA/CNS Student Conference,** a showcase for some of the brightest young minds studying nuclear related subjects.

A number of items are included in the **General News** section which we hope that you will find interesting and not too repetitive from other sources.

And, of course, there are reports of many activities of the Society and its members in the **CNS News** section.

To whet your appetite to attend , the preliminary programs for the **CNA and CNS Annual Conferences** being held in Montreal this June, are included.

Finally, we hope you notice the various advertisements in this issue. It is our belief and that of the CNS Council that appropriate advertising can be of interest to readers as well as income to the Society.

We welcome your comments, contributions, even criticism.

F. B.

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Cover Illustration

The photograph on the cover is a very recent one, taken by Atomic Energy of Canada Limited's photographer, Mel Loynd, of the two reactor buildings at the Qinshan site in China, provided through the courtesy of Stephanie Lakin in AECL's marketing group.

(Photo courtesy of AECB)

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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 60.00$, 35.00$ pour les retaités, et 20.00$ pour les étudiants.

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VIEWPOINT

To Air is to Err

by J.A.L. Robertson

Ed. Note: *Many readers will recognize the name of Archie Robertson, a retired senior researcher at AECL's Chalk River Laboratories, as the author of the two-part critique of the Environmental Assessment Panel on Nuclear Fuel Waste ("Seaborn" panel), published in Vol. 19, Nos. 2 and 3 under the title "Malice in Blunderland". Now he has waded in against the Canadian Broadcasting Corporation for its systemic negative portrayal of nuclear energy. Following is the text of Robertson's verbal presentation to a hearing of the Canadian Radio Television Commission held in Sudbury, March 16, 1999. That presentation was just a summary of a 32 page report he compiled and submitted to the CRTC. Archie Robertson can be reached by e-mail at < arobertson@intranet.ca >*

My purpose is to provide the CRTC with evidence of persistent bias against nuclear energy by the CBC, to analyze the forms taken by this bias, to suggest possible root causes and to recommend remedial measures. The relevance to the CRTC of this submission on a single issue is that there is evidence that the bias may be much more widespread, extending to industry and elsewhere.

I recognize that there is still much that is good in CBC programs, and do not wish to destroy a once-respected Canadian heritage. I come neither to praise nor to bury CBCers. I hope that this submission may help the CBC restore its credibility and re-earn the trust of a large segment of the Canadian public. The CBC's mandate is to unite Canadians: satanizing the nuclear industry and other sectors of society is divisive.

The 32-page printed version of my submission documents evidence of systemic anti-nuclear bias exhibited by the CBC. Three major observations jump out from the evidence:

1. The staggering number of instances of insidious and invidious bias.
2. The fact that these have persisted for a quarter of a century.
3. The failure by members of the public to obtain redress through all available channels.

I analyzed the evidence into six categories:

1. Simple falsehoods, which are relatively infrequent.

   About equally responsible for the bulk of the evidence are the next three:
2. Misleading statements, distortions, unfounded allegations and opinions stated as fact.
3. Selectivity, particularly in the choice of those interviewed and in the time accorded them.
4. Prejudicial behaviour of program hosts.

The two others, though less frequent, are more serious:

5. The long-standing practice of the CBC to allow staff with allegiance to anti-nuclear organizations to participate in the production and presentation of programs on this issue.
6. The exploitation of psychological means that create anti-nuclear impressions in the audience, such as docudramas, eerie music, clips of a mushroom cloud to illustrate programs on peaceful nuclear energy and other forms of scare-mongering.

The analysis includes instances of the CRTC failing to correct such abuses when they were brought to its attention.

In seeking root causes of this bias against nuclear energy I suggest that much of it can be assigned to ignorance rather than malice. The media in general, and the CBC in particular, are mainly drawn from the liberal arts community, one often antipathetic if not antagonistic to industry and technology. As such they are susceptible to claims by well organized anti-nuclear groups, and unqualified, through lack of mathematical and scientific training, to challenge them. Many of those now controlling the media were brought up in the 1960s, uncritically importing the US's anti-military, anti-police, anti-establishment attitudes that were sometimes appropriate there, but not in Canada. A generally low standard of media ethics, characterized by "the end justifies the means", contributes: if the producers and hosts believe that nuclear energy is evil then they can convince themselves that they should expose this to their audiences. "Watergate-envy" leads them to present anything they learn as an expose, and to find conspiracies where none exists.

Much less defensible is the concealment of a conflict of interest on the part of producers and hosts. I doubt that people watching a "The Nature of Things" program on nuclear energy realize that the CRTC has stated that "the Television Broadcasting Regulations, which prohibits the broadcast of false or misleading news, does not apply to a program like (this)", or that the host, David Suzuki, was on the Board of Directors of the leading anti-nuclear organization. Max Allen, producer of another anti-nuclear program was also a member of that organization. If the CBC is aware of this bias it is in violation of its own "Journalistic Policy"; if not, it is not competent to provide programming on this issue, despite its avowed intention to provide "enlightenment". Either way, it is presumably in violation of the Broadcasting Act that requires that "programming ... be of a high standard". It is journalism like this that gives libel chill a good name.

I allege bias on the part of the CBC in its treatment of nuclear energy. The CBC has denied this and has assured the CRTC in writing that it monitors for bias. There is a simple means of resolving this conflict:

The CRTC should require the CBC to table at these hearings the results of its monitoring, so that the CRTC and the public may adjudicate between the CBC's claims and mine.

Most of my other recommendations are couched in terms applicable to all controversial issues, not just nuclear energy.

The CRTC should require the CBC to:

- recognize and acknowledge bias by the CBC in its treatment of nuclear energy,

- enforce existing policies,
- eliminate from these policies exemptions for contract staff and for "documentaries",
- exclude from the production and presentation of a program on an issue of public concern anyone who has taken a public stance on that issue, either as a proponent or an opponent,
- monitor for balance on issues of public concern,
- introduce some platform for corrections,
- provide a publicly accessible log of complaints including their disposition, ideally available through the internet,
- maintain a publicly accessible list, ideally available through the internet, of individuals called on for interviews on issues of public concern, identifying each as for or against, or neutral, and
- issue an annual report summarizing these complaints by issue, giving statistics.

To ensure that the CBC corrects its errors, the CRTC should:

- improve its monitoring of CBC compliance with requirements,
- be more diligent in investigating complaints,
- invoke sanctions for repeated infractions,
- review the CBC's "Journalistic Policy", publish its findings and require the CBC to make revisions if appropriate, and
- incorporate the CBC's "Journalistic Policy", and possibly other documents, in the CBC's licence.

Some examples of the evidence are:

A producer told a host to "Emphasize things scary".

Three high profile hosts admitted to ignoring the CBC's "Journalistic Policy".

A nuclear spokesman was de-invited because the nuclear critic had left town but the anti-nuclear interview was put out anyway.

A professor was de-invited when he failed to provide the alarmist quotes wanted.

The CBC repeatedly refers to thousands of deaths from the Chernobyl accident and ignores the figure of less than 50 agreed by a conference of 845 scientists sponsored by the UN.

One program even claimed a death toll of 50,000 from the Three Mile Island accident, compared with the generally accepted figure of one person who may eventually die.

A docudrama pretended that a Chernobyl-like accident had occurred near Toronto.

Such scary misinformation is partly due to selective interviews with anti-nuclear activists, introduced as experts but regarded as mavericks by their peers; and without any opportunity for rebuttal.

One high profile host, David Suzuki, repeatedly attacks nuclear energy and promotes conservation, concealing that airtight dwellings could expose occupants to more radiation from radon gas in a year than they would get from nuclear energy in a lifetime.

To finish I will summarize in a parody of a CBC broadcast:

> "Today at Sudbury a public hearing into the CBC's performance learned of systemic bias in its treatment of issues of public concern. A 32-page expose by an honoured scientist documented abundant evidence of bias extending over 25 years. Among his examples of scare-mongering, the CBC has repeatedly exaggerated the death toll of accidents by a factor of at least 20, and once 50,000. He argued that the CBC appears to be in violation of the Broadcasting Act and challenged it to make public the results of monitoring for balance that it has claimed to do, as required by the CRTC. It was revealed that card-carrying members of a pressure group active in these issues have operated within the CBC for at least 20 years, employed on the production and presentation of programs on these issues. We have obtained copies of letters showing that the CRTC was made aware of the bias, and the existence of 'moles' within the CBC, as long ago as 1988, but it chose to take no action."

Tracy, Quebec: The first of two CANDU nuclear reactor cores for Qinshan, China, rolled out on April 15, 1999. The calandria, designed by Atomic Energy of Canada Ltd, was manufactured by Alstom Canada Inc. in Tracy, Quebec, under a subcontract to Canatom NPM, and will reach China in mid-June on a Chinese freighter. In total, the Qinshan project will result in $1.5 billion in revenue to Canadian private sector companies for goods and services, and 27,000 person-years of employment over the life of the project. *Photo courtesy of Ian Salgo, Canatom NPM.*

LETTER TO THE EDITOR

Radiation Protection: Living with a Threshold

The Editor:

I was astonished by a statement in the last paragraphs of Dr. Osborne's paper (Oct-Dec 98):

> "We need to be clear that radiation measurements, dosimetry, and environmental modeling would become much more complicated with a departure from an assumption of linearity of dose and response for protection purposes. The instruments and models would need to be much more clever than the ones with which I have been involved in my near four decades. Operational protection, too, would be much more complicated."

How could this be? As the LNT drags us down to ever more trivial levels, the scenarios grow increasingly Byzantine in their complexity. Swedes were told to stay in their houses to avoid Chernobyl's lethal fallout, but were also told that the natural radon in their houses was many times more hazardous than the fallout. No other industry even attempts to control the immeasurably infinitesimal, decades below where any deleterious effects are observed and scarcely detectable against the large and varying natural background. The nuclear field has created a situation where any amount of radiation, however trivial, is deemed worthy of a long and lucrative study. But how long can we, with integrity, carry out "scientific" studies based on such a unscientific premise? To stop calling for such studies would be a much-needed step toward a simpler and more reasonable enterprise.

It is understandable that persons making such studies, and companies carrying out the multi-billion dollar "remediation" projects they recommend, are concerned about the economic impact of changing the ground rules. But all progress faces such problems, and the people like Dr. Osborne who stepped into this field when it was still emerging have the intelligence, the imagination, *and the unique skills,* to move to the more fruitful efforts of converting radiation protection form a purely economic drag to a tool for improving efficient and profitable operation. For example, perhaps one or two workers could do the job now done by dozens of workers, each allowed only minutes or seconds to carry out a simple task in a radiation field, each creating contaminated clothing, tools and materials. That would certainly reduce, not add to, complexity.

Is it really simpler to design and operate radwaste handling and storage facilities when we must postulate that the diffusion of a few single atoms of plutonium through miles of desert sand will "contaminate" a water supply a million years hence? Do we simplify things by telling people that irradiating large populations with trivial doses will somehow cause thousands of deaths, even though no individual is harmed? Does it make it simpler to pretend that radioactive materials pose unprecedented hazards because they stay toxic for thousands of years, while we continue to deal routinely (and generally adequately) with non-radioactive toxins such as arsenic, selenium, cadmium, lead, *et al.* that remain toxic forever? Why should we tell people (as we did at Banff last year) that living near an Ontario Hydro plant created a greater chance of death than being killed in a fire? We have long lists of people by name who die each year in fires; do you know anyone who was killed by a Western-style nuclear plant?

Richard Osborne

We have to replace the LNT with a model that more accurately represents the scientific data. We should treat radiation as we do other hazards: set permissible limits well below where deleterious effects have been observed – perhaps 10 rad (0.1 Gy) per year. Below that, we begin to infringe on radiation levels that large numbers of people have lived in healthily for generations. The linear hypothesis did little harm during the years we were developing criteria and procedures to protect against radiation in the demonstrably dangerous range. But its extrapolation now, decades below this range, has created a monster that must be slain. Along with the LNT, the notion of "collective dose" must also be abandoned. Its only excuse was when we feared that genetic effects from low-level radiation might be a problem. Now that we know it isn't, applying the concept to cancer is indefensible. It should be repudiated.

Ridding the world of unfounded fears of low-level radiation will also us to concentrate on the real problems and opportunities of nuclear technologies. And it will help restore integrity and credibility to science and to government that are being increasingly damaged by the current radiation standards and their defense, which affront both science and common sense. The public may not readily accept our conclusions. But we cannot expect the public attitude to change until we have done our part to state the facts as we see them.

Theodore Rockwell
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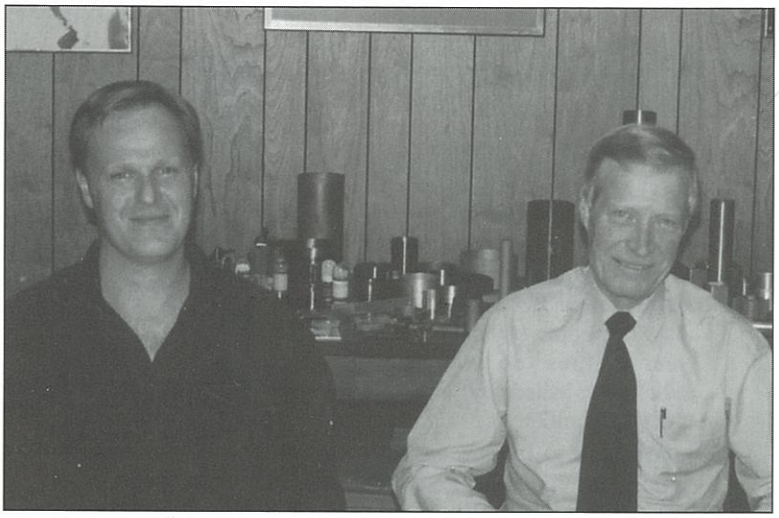
Ed Note: *Dr. Rockwell is currently vice-president of "Radiation, Science & Health Inc." and has been, for several years, a strong advocate for disbanding the "linear, no-threshold" (LNT) concept for radiation effects on humans.*

Nu-Tech - maker of pressure tubes for CANDU



David Schreiter (L) and Syd Aldridge are shown in the board room of Nu-Tech Precision Metals in Arnprior, Ontario. Behind them are samples of the many items the company produces from a variety of metals.

A distinctive feature of CANDU reactors is the use of pressure tubes. These critical components hold the fuel and carry the hot, pressurized primary coolant. Reliable and predictable performance of the pressure tubes is essential for the economic competitiveness of CANDU nuclear power plants.

All of the pressure tubes for CANDU reactors, here and abroad, have been produced by a modest sized company located in Arnprior, Ontario, a town about 60 kilometres west of Ottawa, **Nu- Tech Precision Metals Inc.** Over the years the company has produced about 17,000 pressure tubes which have been installed in 40 reactors worldwide.

Established in the 1960s as Chase Nuclear, a subsidiary of the large American firm Chase Brass and Copper Co., the Arnprior plant and a companion one in Waterbury, Connecticut were purchased by six investors in 1985 and a new Canadian company was created under the current name. Since then the company has diversified its product line but CANDU pressure tubes still are a major part of its business.

Heading the firm is an experienced metallurgist, Syd Aldridge, who joined the organization in 1977 after 14 years at the Chalk River Laboratories of Atomic Energy of Canada Limited. His manager of the Extrusion Division, which manufactures the CANDU pressure tubes, is also an alumnus of CRL. David Schreiter joined Nu-Tech about three years ago after also serving 14 years at the Chalk River Laboratories.

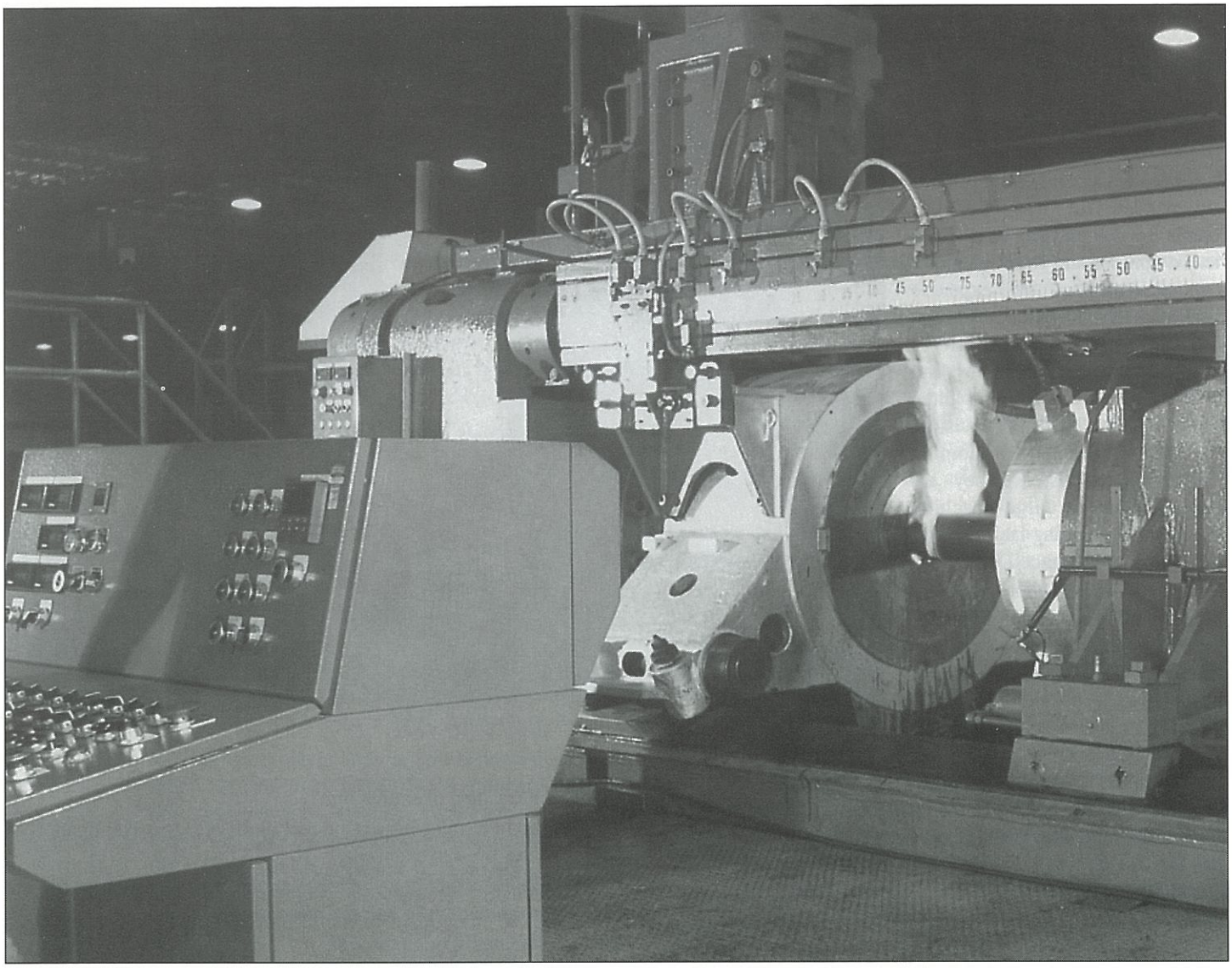
Until a few years ago the Arnprior plant did only the cold drawing, finishing and final inspection of the pressure tubes, with the extrusion of the tubes from billets being done in the American plant. When the order came for pressure tubes for the Qinshan reactors in China in 1996, American political policy entered the picture, through that country's embargo against nuclear components for China. Aldridge relates that initially it was proposed to move the large extrusion press from the Connecticut plant to Arnprior but, due to the age and condition, this was not a viable option. A newer and larger press was located in Germany, still unassembled. A frantic period ensued, to build an addition to the plant building in Arnprior and to arrange for the shipment and subsequent assembly of the new press. This project was started in May of 1996 with the pouring of the press foundations and the first tube was extruded in February 1997. The existing plant, built in 1974, had about 40,000 sq.ft. of space. With the addition for the new press, the plant size was essentially doubled.

In an earlier 1988 move, Nu-Tech bought the nuclear division of Bristol Aerospace which previously autoclaved the finished pressure tubes. The autoclave was installed in Arnprior and, with these two moves, Nu-Tech now has the capacity at its Arnprior plant to extrude pressure tubes from raw billets and completely finish them for installation in CANDU reactors.

Figure 1 is a basic flow chart for the overall production of CANDU pressure tubes, taken from Reference 1.. Nu-Tech begins its operations with the machined billet but is responsible for ensuring the metallurgical specifications throughout the full process

The stand of the United States government against China also required Nu-Tech to find a new source of the raw zirconium - 2.5% niobium alloy billets. Over the years the billets had been obtained from Teledyne Wah Chang, in Albany, Oregon. For the Qinshan project the billets are being purchased from Russia. When questioned about the quality of the Russian billets, Aldridge points out that it was Russia (then part of the USSR) that first developed the zirconium - 2.5% niobium alloy in the 1950's for use in their own nuclear reactors.

Aldridge is the author or co-author of a number of



Flaming lubricant highlights the large press at Nu-Tech Precision Metals while extruding a CANDU pressure tube.

technical papers related to the production of pressure tubes for CANDU reactors. A recent one dealt with the harmful effects of trace elements (Reference 1). The problem of delayed hydride cracking due to excessive hydrogen is one example. (As most readers of the CNS Bulletin know, delayed hydride cracking caused failure of tubes in the earlier Pickering NGS reactors.) A quote from Reference 1 expands on this.

> *For delayed hydride cracking to occur in Zr-2.5Nb pressure tubes, the following must be present at the same time:*
>
> *a large tensile stress*
>
> *a crack initiator, and,*
>
> *hydrides, the presence of which indicates that the hydrogen concentration is greater than the solubility limit of hydrogen in zirconium at the temperature of interest*
>
> *During reactor operation, the hydrogen concentration in pressure tubes gradually increase, primarily from the pickup of some of the deuterium that is released in the corrosion reaction with the D2O coolant at the inside surface. It is, therefore, desirable that new pressure tubes have low initial hydrogen concentrations to ensure that the equivalent hydrogen concentrations that would cause hydrides to be present at operating temperatures are not reached throughout the design life.*

The specification for the maximum concentration of hydrogen in the manufactured pressure tubes was reduced five-fold in 1992 to 5 ppm (wt). This has been achieved by using a quadruple melting process in preparing the primary ingot from the initial zirconium sponge and through very careful control of all of the subsequent manufacturing operations.

Aldridge was presented with the *Russ Ogden Award* by the American Society for Testing and Materials in May 1998 for his work in the area of reactive and refractory metals and alloys.

Since pressure tubes are primarily needed for new CANDU plants the demand has been erratic. To compensate for this, and to capitalize on Nu-Tech's expertise with non-ferrous metals, Aldridge has led the company into a number of other processes and products. Nu-Tech now has three divisions: the Extrusion Division, the Tube Division and the Joining Technology Division. They are supported by a large machine shop, metal finishing facilities and the Quality Assurance Dept.

Ultrasonic inspection is carried out on finished CANDU pressure tubes.

As well as CANDU pressure tubes, Nu-Tech is currently manufacturing the cylindrical and hexagonal flow tubes in addition to the absorber assemblies for the two MAPLE reactors under construction at the Chalk River Laboratories. These components involve all three divisions of Nu- Tech and are similar to the ones manufactured by Nu-Tech for the Korean HANARO research reactor (which was based on the MAPLE design).

The Extrusion Division of Nu-Tech is now a major supplier of seamless titanium tubing and pipe for the US and European market. It also manufactures co-extruded clad products which includes titanium clad copper conductor bars for corrosive environments as well as extruded composite rods for drawing into super-conducting wires. The Division can produce extruded shapes from high-performance titanium and zirconium alloys and from niobium, tantalum, hafnium, tin and calcium.

A central element of the Joining Technology Division is its electron beam welding facility which can join a wide range of reactive materials in almost any shape. The Division also has several other welding processes, such as: gas metal arc; fluxed core arc; gas tungsten arc; and plasma arc. These processes are automated wherever possible by the use of jigs and fixtures and the pulsing capabilities of the power source. This Division has recently been awarded its "Approved Maintenance Organization" status by Transport Canada for welding and NDE of aircraft components.

As could be expected at a company producing key nuclear components Nu-Tech has extensive Quality Assurance and Quality Control programs. The company uses a wide range of non-destructive evaluation techniques and has personnel qualified in:

- ultrasonic examination;
- eddy current inspection techniques for the examination of non-ferrous materials;
- liquid penetrant and magnetic particle inspection for the examination of surface discontinuities, and,
- radiographic inspection..

The company's Quality Assurance program has been audited to the definitive Canadian standard, CAN3-CSA-Z299.2 and the plant more than meets the requirements of ISO 9002. The QA Dept. is currently preparing for re-certification under ASME Section III.

Because of Aldridge's diver-sification, Nu-Tech Precision Metals Inc. is on a good financial basis meaning that there is a high degree of assurance that its expertise will be there when the next orders for CANDU reactors materialize and more pressure tubes are needed.

Reference

Fabrication of Zr-2.5Nb Pressure Tubes to Minimize the Harmful Effects of Trace Elements by James Theaker, Ram Choubey, Gerry Moan, Syd Aldridge, Lynn Davis, Ronald Graham, Christopher Coleman.

American Society for Testing and Materials, Standard Technical Publication 1245. 1995.

Hydrogen and Nuclear Energy

by R.B. Duffey[1], A.I. Miller[1], and W.T. Hancox[2], D.R. Pendergast[2]

Ed. Note: *There is a concerted effort on the part of several people within the nuclear community to ensure that nuclear power is recognized as an essential element in any program to meet the commitments made at Kyoto in 1997 to reduce the emissions of "greenhouse gases". Much has been said in the media about a "hydrogen economy" while ignoring the source of the hydrogen. The following very recent paper discusses in detail the role nuclear power could play in producing hydrogen for transportation, the source of most of the greenhouse gases.*

Abstract

The current world-wide emphasis on reducing greenhouse gas (GHG) emissions provides an opportunity to revisit how energy is produced and used, consistent with the need for human and economic growth. Both the scale of the problem and the efforts needed for its resolution are extremely large. We argue that GHG reduction strategies must include a greater penetration of electricity into areas, such as transportation, that have been the almost exclusive domain of fossil fuels. An opportunity for electricity to displace fossil fuel use is through electrolytic production of hydrogen. Nuclear power is the only large-scale commercially proven non-carbon electricity generation source, and it must play a key role. As a non-carbon power source, it can also provide the high-capacity base needed to stabilize electricity grids so that they can accommodate other non-carbon sources, namely low-capacity factor renewables such as wind and solar. Electricity can be used directly to power stand-alone hydrogen production facilities. In the special case of CANDU® reactors, the hydrogen streams can be pre-processed to recover the trace concentrations of deuterium that can be re-oxidized to heavy water. World-wide experience shows that nuclear power can achieve high standards of public safety, environmental protection and commercially competitive economics, and must be an integral part of future energy systems.

Introduction: The Need For Synergistic Approaches

We need to manage the environment of our planet, so that we may continue to live on it. Man is affecting the environment in a significant and sometimes worrisome way. The effects of humans on the environment are becoming clear, by whatever measure is used (population, temperature, species count, deforestation, atmospheric gas concentrations, freshwater sources, etc.). Some of the environmental problems identified, such as pollution of the ocean and atmosphere, transcend national boundaries. It is difficult for governments to take actions to protect these global commons; this very lack of action may adversely affect the economic and political survival of all nations. Much of this ground has been covered elsewhere: we focus on issues associated with man's use of energy. Many of the problems identified, in particular increasing levels of greenhouse gases in the atmosphere, are attributed to the use of energy. Energy use, per se, is not fundamentally contrary to protection of the environment. It is the uncontrolled release of products associated with energy production and use that can adversely affect the environment. In fact, man's harnessing of energy sources can be directed to improvement of the environment. We now have a real opportunity to revisit how we produce and use energy, consistent with the need for human and economic growth and protection of the global commons.

The recent global and national debate on reducing and hence managing greenhouse gases and other emissions has centred on a number of issues. The real problem is to find ways to reduce the effects of emissions without requiring onerous or expensive restrictions on needed industrial or economic growth, and to find feasible ways to enhance emissions management technology. If industrial processes become more expensive then one cannot compete in a global economy; therefore, market forces and consumer needs have to be also included. But there is no consensus on how to achieve effective management of our shared environment, only a realization that something must be done. This realization has spawned many and varied research programs to enhance energy efficiency and to reduce emissions.

Thus "Green" initiatives include development of sustainable or eco-friendly growth, growth with the minimum impact on the environment. However, many of these initiatives are costly: they require drastic changes

1 Atomic Energy of Canada Limited, Chalk River Laboratories, Chalk River, ON

2 Atomic Energy of Canada Limited, Mississauga, ON

in social, economic and energy use patterns, and would imply or call for a return to a more eco-friendly or "simpler" society. Either indirectly through added costs or directly through relinquishing elements of current lifestyle, this simpler society can easily be a poorer one. The proposed measures include increased taxation, more restrictive laws, mandated reductions in energy use, and large increases in end-use energy efficiency (Suzuki Foundation and the Pembina Institute,1998). Indeed, the Canadian Government has explicitly advocated significant change such that:

> "All Canadians need to make changes in the way they generate and use energy, how they move people and goods, how they heat their homes, and how they produce goods. With this in mind, NRCan's climate change efforts are aimed at moving the market toward improved energy efficiency, developing alternative energy markets and focusing R&D resources on providing technology solutions to this global challenge."
> Energy: Exploring New Avenues In Energy Efficiency
> Source:http://www.nrcan.gc.ca/gcc/english/html/feature/energy.html

None of this is new. The reason for concern over the potential outcome from such a program is apparent from Figure 1. To date, growth of the World economy expressed as the Gross World Product (GWP), is highly correlated with the measured growth of CO2 concentrations in the atmosphere, unsurprisingly so since world economic growth in the 20th century has been based on carbon fuels. No country is immune: Canadian growth shows the same trend (see Figure 2), as one would expect for a country so dependent on world trade. Since economic growth is so tightly coupled to energy production, unthinking reduction in energy production could very easily lead to grim economic consequences. Conversely an awareness of this effect could provide a powerful constraint on policies to reduce greenhouse gas emissions. The obvious way of escaping this dilemma would be to deploy technology that decouples energy production from greenhouse gas emissions. Without intelligent use of technology, any country attempting significant (beyond nominal, voluntary measures) restrictions on emissions would likely experience a totally unacceptable economic effect (Imperial Oil, 1998).

Solutions and measures that would undermine national economies and threaten the survival of large corporations are surely not what is wanted considering the other large changes that most people would regard as unavoidable. Thus there is a generally accepted need for substantial, continuing growth in the world's developing economies. Then, the world's economies are going to have to bear both costs of whatever adaptations are made to reduce greenhouse gas emissions for the long-term and, likely, interim costs to offset the cumulative effects of the emissions. Policies that would achieve a 1% reduction in the GHG concentration in the atmosphere through a 1% reduction in the world product and world trade are surely unworkable.

If that is the only option on offer, it is hardly surprising that

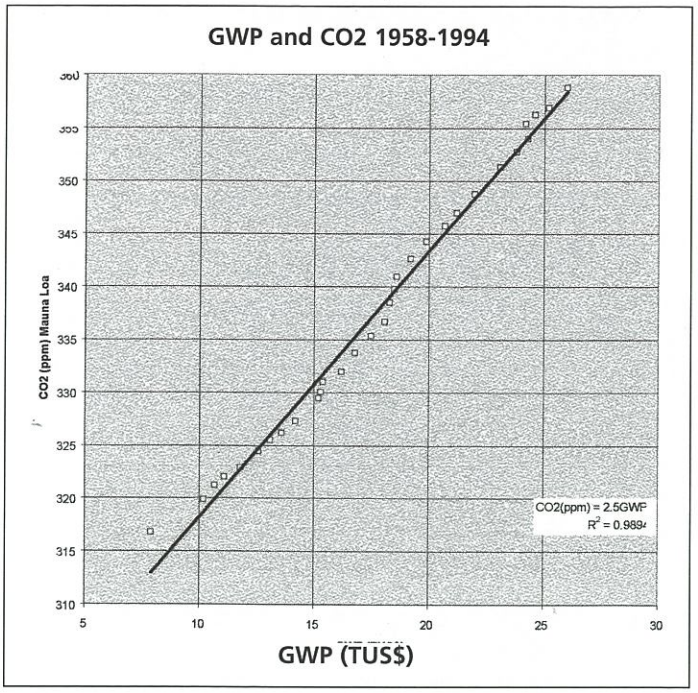


Figure 1: Global Economic and Atmospheric CO2 Concentration Trends

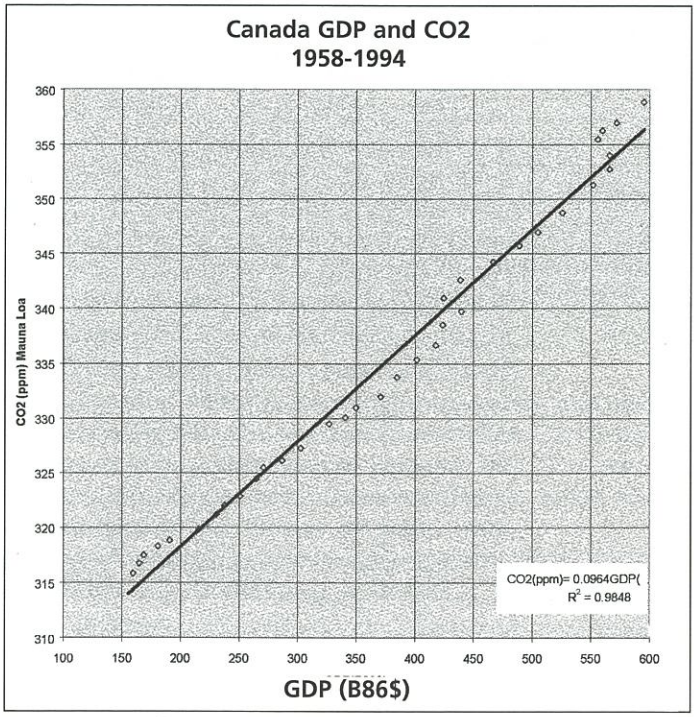


Figure 2: Canadian Economic and Atmospheric CO2 Concentration Trends

emissions in Canada continue to grow steadily (see Figure3) and are projected to maintain this trend. Energy-intensive industries are clearly "emitters", with many kinds of waste streams. As shown in Figure 4, unrestrained open-market use of both petroleum and natural-gas continue to grow, and hence lead, inexorably, to increased GHG emissions.

Just as an individual's or a nation's wealth is expressed in various "currencies", various "energy currencies" are used (Scott, 1994-1996). Some of these (e.g., oil and natural-gas, coal, hydraulic, nuclear, wind and solar) are primary forms of "energy wealth". In developed societies in particular, these are extensively converted into more convenient forms of "energy currency" (e.g., refined liquid fuels and electricity as well as, less obviously, every conceivable form of finished goods). To avoid reduction in energy wealth and all the adverse effects that this would entail, we need to concentrate on ways to displace the GHG-emitting primary energy sources with sources that are zero or near-zero GHG emitters. Those sources are nuclear, solar, wind, hydraulic and other renewables. Apart from possible direct use of nuclear as a heat source, these are electricity producers. They can reduce emissions in the electricity generation sector but cannot directly influence almost all of the transportation sector and substantial parts of the industrial sector, together responsible for almost half the total GHG emissions (see Figure 3). The consequences of this limitation are even larger than they seem since a substantial part of the remaining GHG sources (e.g., space heating) occur as ill-distributed demands that are best addressed by energy currencies that are easily stored.

To avoid all the adverse effects of throttling these parts of the global economies, we must add a flexible, storable energy currency to deployment of more of the near-zero GHG electric sources. Rechargeable batteries have been the subject of huge development efforts without producing a significant breakthrough in the prospects for storage of electricity in these electrochemical forms. While electrochemical cells will likely grow slowly as an energy currency, it is hydrogen, particularly when used in a fuel cell, that seems to offer the most alternative energy currency.

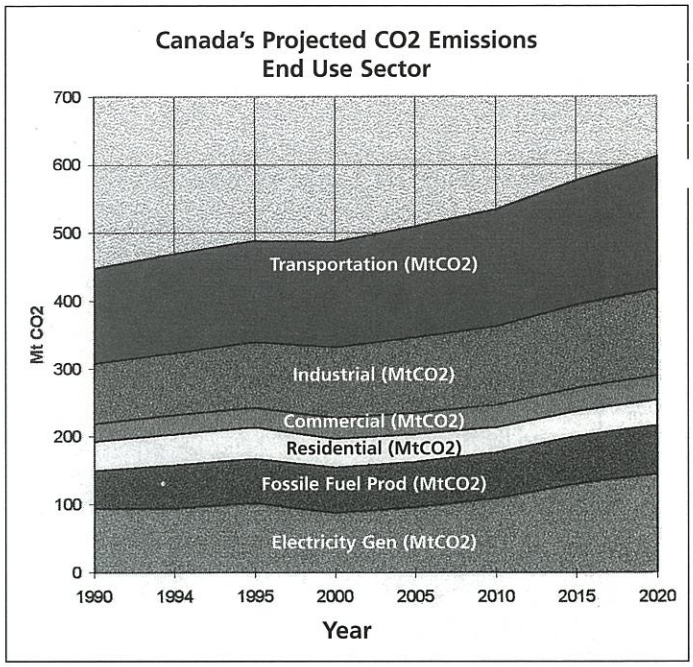


Figure 3: Projections for the Future

Although the opportunity for hydrogen is not necessarily confined to transportation, it is transportation that provides the largest opportunity for the synergism of hydrogen and near-zero GHG electricity. The extensive US study on this topic (Berry, 1996) states that: "As the ultimate fuel, hydrogen, once established, will provide a single transition to a stable alternative fuel, protecting long-term development and investment in alternative-fuel vehicles and infrastructure...a transition to hydrogen

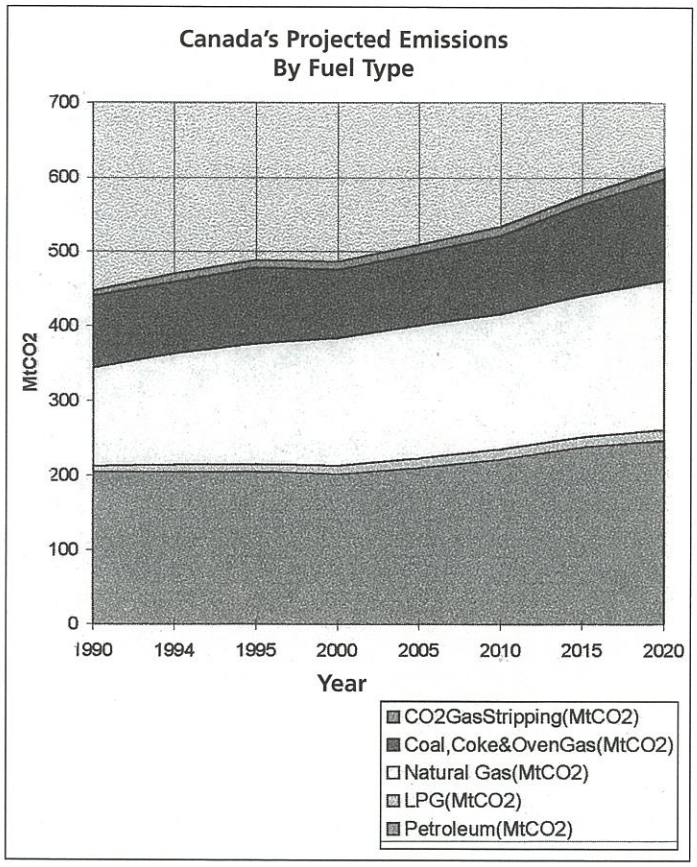


Figure 4: Historical and Future Emissions from the Use of Carbon Fuels

vehicles...would last for the foreseeable future".

So for transportation, if we are to provide consumer choice, efficient open markets, and reduce emissions, how do we also balance and meet the global requirements?

Nuclear, Hydrogen And Renewable Energy Sources

It appears that nuclear and other renewable energy sources and hydrogen are uniquely synergistic in reducing potential costs, electricity generation emissions and end-use transportation emissions. This potential synergism is largely unexplored today, because of historical use patterns and the competing self-interests among the various proponents. The potential needs to be exploited as a bridge towards tomorrow.

Nuclear energy is currently in a paradoxical situation. Although it is the only technology so far to have produced large reductions in GHG emissions in Canada and the world, nuclear energy is relegated in the emissions debate either to be ignored or dismissed. Yet it is the only non-carbon source whose increased use is capable of replacing carbon (coal, oil and gas) sources. The pure renewables will gradually grow within the energy mix but without additional nuclear capacity, it will be impossible even to hold greenhouse gas emissions near current values without enormous economic disruption. Nuclear electric is the largest proven non-carbon emitting sources in the world today. Yet the reports cited above (Berry,1996; Suzuki Foundation and Pembina Institute, 1998) and other reports (NRCan,1998; USDOE,1998) do not include significant non-carbon nuclear energy in the future energy scenarios or emissions-reduction measures. In the Suzuki Foundation and Pembina Institute, (1998) report, large claims are made for as yet unproven measures and increased taxation and legislative measures to protect the environment, yet the word nuclear appears nowhere as a "Canadian Solution" nor is it considered or admitted to be "green". Where given, the reasons for this omission are usually vague grounds of safety, waste disposal or economics. On examination, the objections are unsupported by facts but related more to the exploitation of fears and misperceptions.

Compromise is impossible with those whose only agenda is the cessation (absolute and entire) of nuclear power, and in whose estimates and visions of the future nuclear power does not figure or appear at all. To many, nuclear power lives in the shadow of nuclear weapons, and is unacceptable on those grounds alone. This view prevails, despite nuclear power providing some 17% in 1995 of the entire world's electricity generation and some 7% of total energy consumption.

Preservation of our environment is in all our interests, and the needs of the environment must be balanced with the needs of all people and societies to grow and prosper. We must be inclusive in our selection and use of energy technology, not exclusive; we will need all energy sources, working together, that are economically viable.

The effects of nuclear power on future emissions reductions are estimated to be upwards of ~50 Mt/CO2 per year in Canada alone (Pendergast et al, 1998); but there are no plans to take wide spread advantage of this. Such plans exist in France and Japan, though not in the United States or Germany. In the latter group of countries, natural-gas plants with reduced capital costs are seen as the alternate power sources. In a "competitive" power market, with no penalties or taxes for carbon emissions, gas turbines from IPP's will be selected as long as natural-gas prices remain at today's levels. In the United Kingdom, this has led to a drastic reduction in coal-burning and what one might reasonably regard as excessive reliance on gas-powered generation.

With respect to safety, the record of the nuclear industry has been and continues to be excellent, as measured by any conventional or relative measure, and personal risk is extremely low. The perception of nuclear safety is dominated in many people's minds by the Chernobyl accident spreading radioactivity over Russia and the Ukraine and wider areas. This accident was for an uncontained plant design, where the standards of safety in design and operation did not match those of other countries when adopted for power generation. The risk of a large accident in a modern western reactor is quite remote, and the chance of any large release highly improbable. On waste storage, as shown by the recent protracted Canadian review, and the studies in Norway, the United States and the United Kingdom, the issue is technically solvable, using deep storage in secure containers. Implementation is embroiled in a continuing socio-political discussion on siting and future generation risks. In fact, nuclear energy waste satisfies a "sustainable criterion" for energy sources because the waste decays naturally to the level

of the original uranium after 300 to 400 years, leaving little more than a geological curiosity. Nuclear fission and fusion reactions occur continuously and renewably in nature, both in the centre of the earth, in the sun, and the cosmos. On cost and relative economics, the generating costs for nuclear energy continue to be competitive with all other sources, even despite the current short-term glut of relatively cheap oil and gas, and the inclusion of the total life-cycle costs of decommissioning and waste disposal.

Hydrogen is also a paradoxical situation. As a carbon-free energy source, it is widely accepted as "green". However, it is currently produced by the use of processes that consume carbon-based fuels with co-production and the almost invariable emission of CO2. The total cycle, therefore, cannot claim significant emissions reductions unless the production process becomes carbon-free. Indeed, the inefficiencies introduced by production, distribution, and end-use of hydrogen may increase overall emissions. For historical reasons, the societal and industrial infrastructure is based on carbon fuels (see Figures 4 and 5). Safety perceptions are driven by images of the uncontrolled burning of the large air ships or exploding tankers. In reality, modern safety standards are entirely adequate. The use of hydrogen in large rocket propulsion is an everyday occurrence; natural-gas is already accepted without question, despite its flammability and explosive hazards. Hydrogen is largely ignored as a potential energy source when emissions reductions are needed. Off-peak electricity, or renewable (electricity-producing) energy sources are often stated to be the appropriate source of the energy needed to produce hydrogen (Berry,1996) using wind farms and solar photo-voltaics, though the economic viability of hydrogen production by electrolysis would be significantly weakened by poor capacity factors. As shown in Figure 6, for the future the comparative cost of the renewable

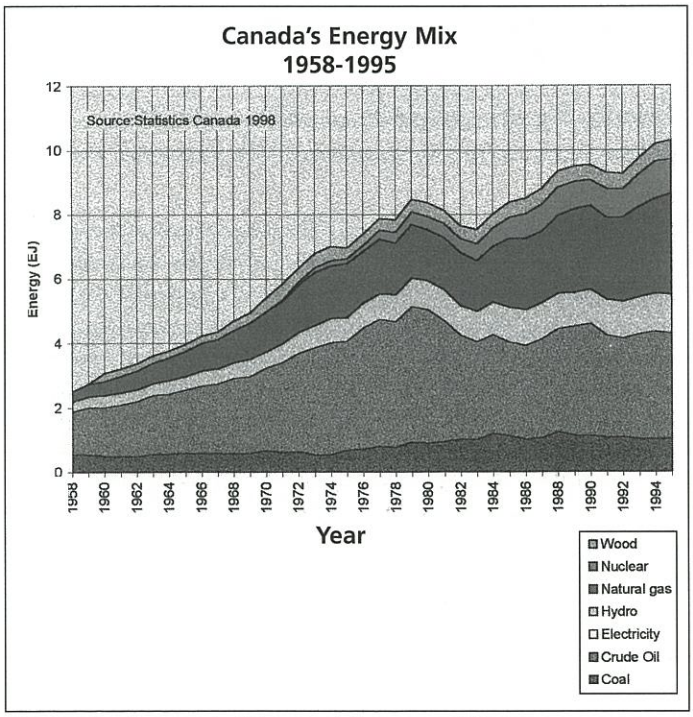


Figure 5: Canada's Historical Sources of Energy

sources is significantly above current competitive market prices (without incentives). If hydrogen supply were to be based on renewable sources such as wind or solar, the principal use of hydrogen in transportation end-use would be then delayed further, even before considering that it would be competing with existing transportation infrastructure.

Finally, renewable energy sources are also in a paradoxical situation. Wind and solar are distributed and intermittent sources of power that require interconnection to alternative secure sources (a grid). The large grid is synergistic because it can provide access to an energy "bank" (i.e., pumped storage or displaced hydro generation) for the electricity generated when it is not immediately needed. Net metering and credits for local generation capacity can be established by means of the grid. Thus although local generation costs may have decreased, the total system cost tends to be higher because storage facilities or backup generation facilities are needed. Limits on the extent of reverse metering by power size to exclude gas turbines (Suzuki Foundation and the Pembina Institute, 1998), also inadvertently exclude large wind farms that must have a (grid) reserve capacity because of the relatively small (~40%) wind farm capacity factor.

Many mechanisms are being introduced to encourage investment in embedded renewable power sources. Hence the concept of "green" quotas - as in Denmark and United Kingdom, or Portfolios, or Capacity Credits - is being legislated as a fraction of the electricity market as an encouragement to help mask or defray the cost. In the United Kingdom, a fossil-fuel levy has been used to support the decommissioning of old nuclear plants and the development of renewable generation, which led to about ~300 MW(e) of wind power. The "level playing field" needed for renewables to compete in the short term must be tilted in their favour. Carbon or emissions taxes - which would encourage greater wind power and solar penetration - also favour nuclear energy and, in part, natural-gas. Competitive power markets favour gas burning and nuclear base-load plants as a relatively cheap and existing measure. But renewables should not have to compete directly with nuclear plants because the perceived and actual end-uses of the electricity generated are totally different and synergistic. Thus, nuclear and some hydro power sources supply a base load and robust grid for large-scale domestic and industrial purposes. Renewable sources provide intermittent power, not necessarily coincident with peaks, load cycling, and local consumption. It will take many decades for renewables to penetrate the energy market significantly (BWEA, 1996) because of the shear scale of the enterprise and the existing need.

Thus to have significant market penetration, wind and solar renewables today must have preferred market share, more cost, significant backup and - most of all - time to develop. Even so, they cannot provide the major share of the energy needed even by the most optimistic proponents (BWEA, 1996) and are also vulnerable to competitive market forces and natural-gas burning.

In Figure 6, we compare estimates and trends for future generating costs from many alternate sources. These values are derived directly from The European Renewables Energy Study (TERES, 1997) and from current actual CANDU values without

allowing for any future nuclear cost reduction. Thus the nuclear estimates are for existing (today's) designs, without assuming any technology enhancements; the renewable estimates assume significant improvements. The European data we use here are of interest because there is already significant wind-energy deployment and experimentation with "competitive" but regulated energy markets, and on market share targets and subsidies for wind farms. Regardless of the absolute magnitudes, which show significant cost increases when adopting renewable sources, the relative estimates in Figure 6 also clearly show that 20 to 30 years are needed for renewable energy costs to significantly decline.

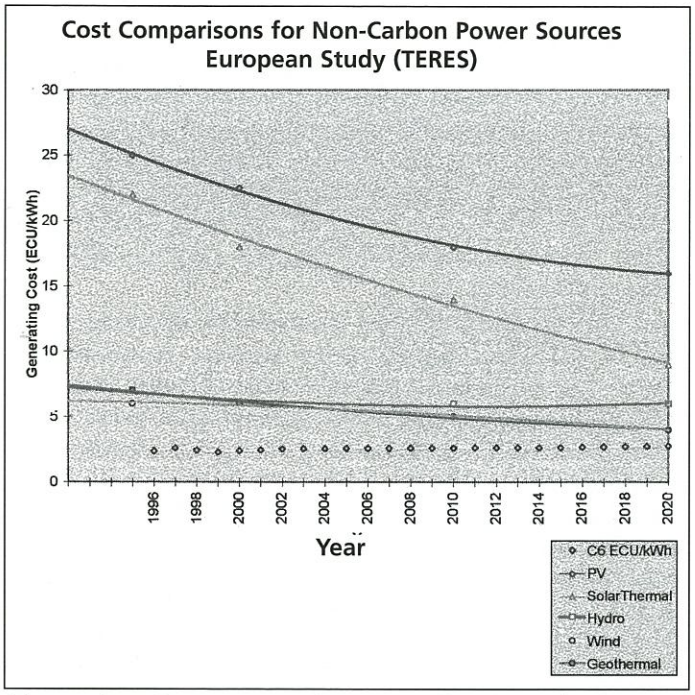


Figure 6: Comparative Current and Projected Electrical Generation Costs

The non-carbon bridge to the future, proposed here, is a balance of hydrogen, renewables and nuclear energy sources, coupled with a management of emissions. The portfolio of electric energy sources is robust in the sense that nuclear is available to back up solar and wind energy, and hydrogen serves as an energy storage medium. The policy measures adopted (which are code words for legislation and taxes) must be implemented in a manner that will not disrupt the economy. It took nearly the whole century to build up the present electrical generating capacity and energy-use patterns: it is an immense enterprise, and it is unreasonable to expect all this to be changed quickly. The present paper argues that a bridge be built to enable changes to occur more naturally over the next 20 to 50 years, without significant economic disruption.

The Nuclear Source Of Hydrogen

As shown in Figure 7, energy use in transportation is about 1.5 EJ/y and is rising. Electricity generation in Canada uses about 3 EJ/y and is also rising, and nuclear electricity generation is currently about 15% of total capacity. Sources of hydrogen usually considered are steam methane reforming, decomposition by partial oxidation or electrolysis.

NRCan (1998) estimates that energy end-use in Canada will grow considerably over the next 20 years, even though the assumed economic growth rate is only 1% ~ 2% per annum. The transportation and industrial sectors show the largest estimated increase.

Hydrogen could provide a significant part of this expanding demand provided it does so in a way that minimizes GHG emissions from the H2 manufacturing. To do so, the production would have to come from non-carbon electricity generation (namely a CANDU reactor). To be efficient in energy production, the reactor uses heavy water (D2O) as its moderator.

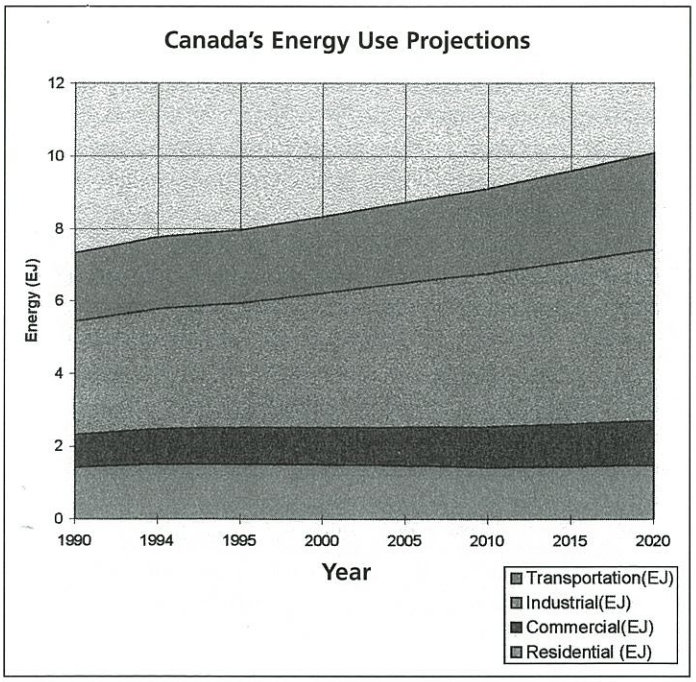


Figure 7: The Present and Projected Use of Energy in Canada

Thus the basic and simple concept is that the reactor is used to generate electricity for the grid, for local or distributed hydrogen production. By-products include heavy water, oxygen and process heat. Where hydrogen production is centralized, nature's providence allows for the very economical production of heavy water during electrolysis of water into hydrogen and oxygen. Heavy water (D2O) is an essential and expensive moderator and coolant component of CANDU reactors. There is, thus, a very substantial additional economic synergy, which significantly reduces capital costs of the CANDU reactor, embedded in the application of nuclear energy to hydrogen production.

Such a reactor design is available as the CANDU 6, which is exported and is also operating in Quebec and New Brunswick. A larger design - the CANDU 9, which is derived from the Bruce and Darlington plants - is also available. In total, 22 CANDU

plants are operating successfully in both Canada and in several other countries (namely Romania, Argentina, Korea). The lifetime average capacity factor is ~65%, and is about 85% for the CANDU 6 designs. Canada is one of the largest exporters of such technology in the world and competes successfully against fossil, gas, and other nuclear generation designs.

With respect to GHG emissions, as shown in Figure 8, CANDU reactors have reduced emissions in Canada by over 1000 Mt/CO2 to date, and continue to avoid emissions by about ~100 Mt/y. Together with hydro power, these represent an essentially zero source of CO2.

Projections show that a fleet of 22 CANDU reactors installed by circa 2020 would meet, with hydro power, all of Canada's estimated needs for electricity and could reduce CO2 emissions by a further 50 Mt/y compared to the most efficient gas-turbine generation. There is no negative economic effect because this additional power generation is needed to grow the economy anyway, according to the NRCan 2020 projections.

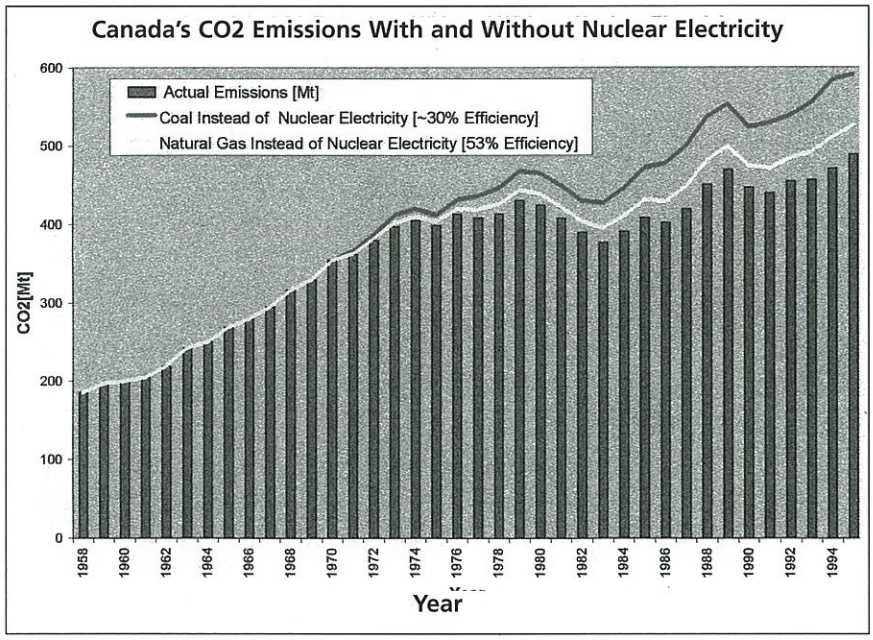


Figure 8: Avoided CO2 Emissions from Nuclear Energy Use in Canada

In fact, the effect on construction, technology and engineering exports would be positive. Without such measures, electricity generation in Canada is predicted to fall, relative to the gross domestic product (GDP) (NRCan, 1998). The drop relative to GDP signifies that relative industrial decline will occur and that the net use of electrical energy in Canada will be reduced (probably resulting in significant price changes for energy).

Hydrogen Generation And End-Use Alternatives

a) Central Hydrogen Generation

One non-carbon concept is to generate hydrogen using a central plant to take advantage of the economies of scale. Hydrogen can then be distributed by tanker or pipeline either as a compressed gas or in a chemically combined form such as ammonia to the local distribution sites (truly gas stations) for final distribution and use. Hydrogen produced in this manner is sensitive to the assumed cost of bulk electricity, which is typically about 25 to 33% of the total H2 cost.

For essentially zero emissions, the preferred and simplest hydrogen production process is electrolysis of water. The costs have been carefully analyzed and show that hydrogen can be produced economically in advanced electrolytic equipment at about 70% efficiency, so that the energy required is order ~50 kWh(e)/kg H2. By-product, D2O, can also be produced using about 50 kWh(e)/kg considering the efficiency and losses in the process.

Using an existing reactor design, it is possible to achieve an 80% operating capacity factor, as has been proven for the CANDU 6 plants. Calculations for a commercial-scale electrolysis plant show that a 690MW CANDU 6 reactor can also simultaneously co-generate about 95 t/y of D2O at that capacity factor. Four or five years of the plants heavy-water production will fill a CANDU system. Since annual consumption resulting from leakage is very small, the system is thus more than self-sufficient in heavy-water production. After 6 or 7 years of production, a plant would provide sufficient heavy water to supply about 4 more similar plants. Thus we have, for each year:

One CANDU reactor @ 690 MW(e)=>95 t/y D2O + 97 kt/y H2.

At today's prices, and to give perspective on the order of magnitude, the hydrogen is valued at about $800/t, using electricity generated at ~2.5 cents/kWh(e), and is hence potentially worth ~$75 M/y revenue at the wholesale site. The D2O by-product is worth about another ~$25 M/y at an assumed market price of $250/kg, giving a total potential revenue or avoided D2O cost of ~$100 M/y.

b) Embedded Hydrogen Generation

Distributed sources are another option, and local small-scale electrolysis has been examined because, in addition to not needing a central facility, local generation avoids transportation costs and large storage containers (Berry, 1996). But electricity supply is still needed, and this need can be derived either from a large grid with central power plants, or from local renewable (wind) power.

It would seem highly desirable to have a local small-scale capability for H2 manufacture. The extra cost of compression locally is also small, say, 10% of the generating cost. As will be seen, the local generation need is quite small. Ideally hydrogen would be generated during off-peak periods of the electricity supply system, thereby better utilizing electrical generating capacity. The pricing structure for electricity could be designed to encourage off-peak use.

Synergism With Hydrogen In Transportation

At present electricity represents a negligible ~0.2% of fuel consumption in transportation, which is the unchallenged domain of oil and gas. Transportation in Canada alone represents some 15% of the GDP, with a total energy use ~1.5 E/J/y causing emissions of about 150 Mt CO2/y, which are projected to rise, as gasoline use rises, to about 200 Mt CO2/y by 2020 (see Figure 9). Canada's fleet of personal vehicles consisted of about 15.5 million cars and light trucks in 1995 (NRCan, 1998). These vehicles alone generated 91 Mt of GHGs expressed as CO2 equivalent in 1995.

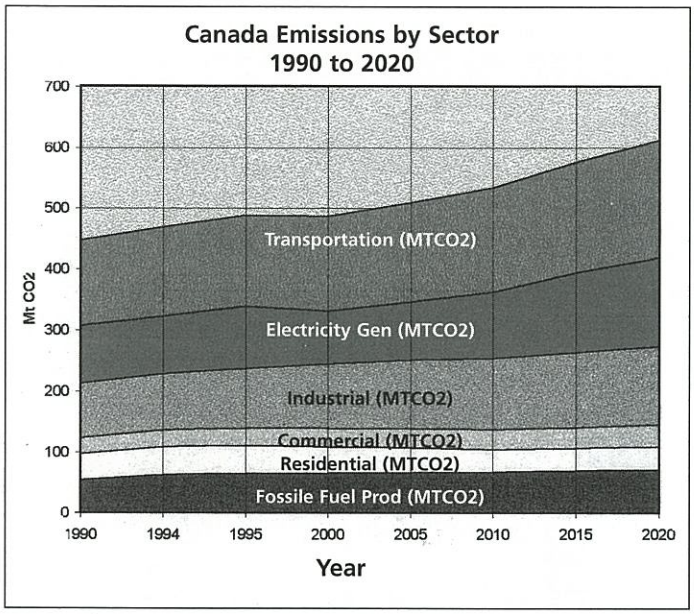


Figure 9: CO2 Emissions Projections by End-Use Sector

The transportation emissions exceed those that are due to electricity production because of the latter's large use of non-carbon power sources. Clearly, help to reduce transportation emissions is needed but without disrupting the infrastructure and the manufacturing capability and its large investment. Refinements to engines, roads, and vehicle design will all help but are unlikely to make gains above the order of ~10 Mt CO2/y: the greatest potential reduction is derived from fuel switching.

Extensive analysis has been undertaken on the costs and benefits of hydrogen as a transportation fuel (Berry,1996) which we do not need to repeat. In principle, it is very attractive and simple. Hydrogen is abundant, and it can be burnt either as a raw gas or by a carrier, or it can be used to feed mobile on-board fuel cells to recombine with oxygen and produce water and energy. The actual vehicle adopted can be from a variety of combinations or choices, e.g., of an internal combustion engine (ICE) fed by methanol, natural-gas or hydrogen, combined with batteries, fuel cells or conventional combustion or both.

Now for hydrogen production, as for everything else, we must consider the entire process from production to end-use, so the carbon dioxide emissions using conventional reforming and electrolysis based on fossil-fuel sources are comparable or even greater than those from simply using gasoline (see Figure 10). Thus there is, significantly, no real advantage to using H2 to reduce emissions, and one might as well burn natural-gas or propane.

The lowest carbon-dioxide-emitting vehicles are the hybrid and fuel cell vehicles. The achievable efficiency of the process is about 50% at the vehicle level (going from combustion to motion). This efficiency immediately gives about a factor of three improvement in the 'equivalent' fuel economy to order 80 to 90 miles per gallon (~2.75 l/100 km).

An Illustrative Canadian Example

From the preceding analysis, there arises an opportunity for a real and distinctive Canadian technological solution to increasing emissions in power generation and transportation. As the basis for this illustrative example, we take the energy, economic and emissions projections published by the Canadian Government (NRCan, 1998) and estimate the potential maximum impact of significant hydrogen-fuelled vehicles on the future.

Consider an average Canadian vehicle, V, driven each day about 57 km/D/V (~21 000 km/y) needing about 0.4 kgH2/d/V for an equivalent 90 mpg. Thus, as we have seen, one 690 MW(e) CANDU 6 operating at 80% load factor can supply ~660 000 V/d with H2 fuel with no net increase in CO2 emissions. So we have

One CANDU @ 690 MW(e)=>95 t/y D2O + 660 000 H2 V/d.

Therefore, a program of 20 CANDU reactors would supply ~13 M hydrogen vehicles, and would be self-sufficient in D2O production, and could supply excess D2O for export. It is likely that fewer than 20 additional CANDU reactors would suffice, as it is likely that off-peak power from the base electrical fleet could be utilized to produce hydrogen. The fuel cell, electrolysis, reactor, and vehicle technology would also be exportable.

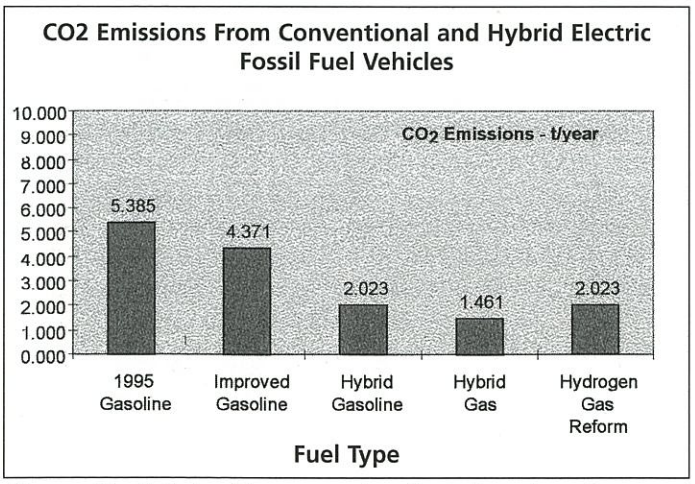


Figure 10: Relative Transportation Emissions from Improved Fuels

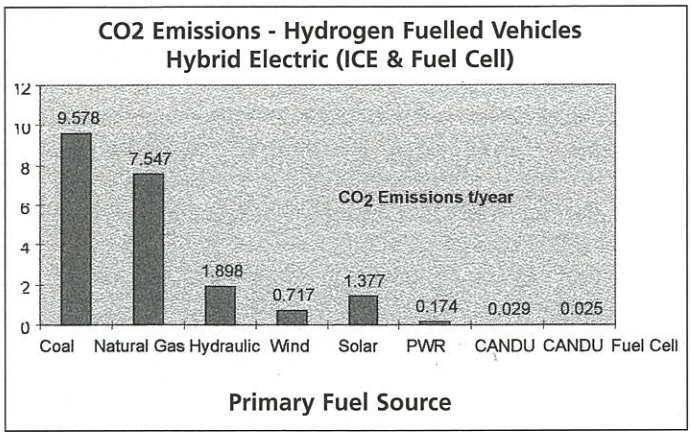


Figure 11: Effect of Non-carbon Sources on Hydrogen Production

As shown in Figure 12, we can simply estimate the potential maximum reductions in Transportation emissions from the present vehicle technological base (petroleum fuels), where we have kept the aviation and rail contributions to transportation unaltered, although those would be every bit as amenable to evolution toward hydrogen fuel. The maximum reduction by 2030 is ~90 Mt CO2/y, and would still be ~30 Mt CO2/y even if a wholesale switch to higher efficiency and alternate-fuelled vehicles were also achieved.

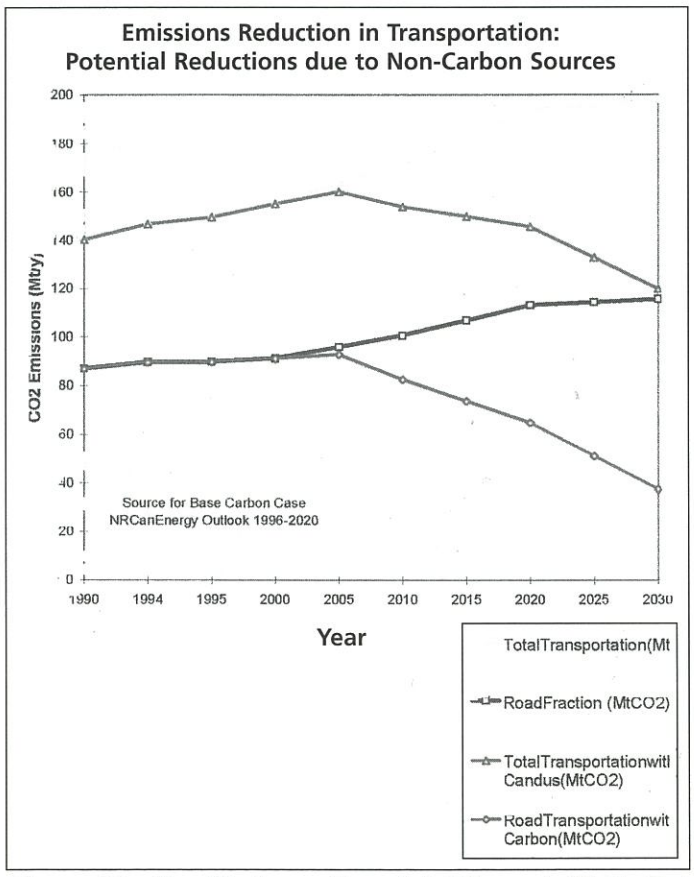


Figure 12: The Maximum Potential Effect of H2-Fuelled Vehicles

In this simplified scenario, the rate of use of H2 in transportation, assuming the availability of fuel cell technology, is governed by the rate of introduction of CANDU reactors. A sensible build-rate is at about one per year, which corresponds as we have seen to ~650 000 H2 V/y, which is about 4% of the vehicle population per year starting in about 2005, and proceeding to a fleet of about 13 M H2 vehicles by 2025.

Up to and beyond that point, at a contribution level of around 10% of the fleet, distributed electrolysis could be introduced using renewable electric supplies (primarily wind power). The required renewable content would then be of order ~1500 MW(e), which corresponds to about 300 distributed farms, which requires a build-rate of the order 10 5 MW-sized farms per year. In context, this is of the order 5 times the present installed UK wind farm capacity introduced over about 10 years.

The traditional measure of energy and electrical usage efficiency in the economy is the ratio of GDP to electricity ($GDP/kWh(e)). This ratio is maintained at its historical low value, of order $1.2/kWh(e), so there is no economic change. The revised apportioning of the forward emissions by sector then would be as shown in Figure 13:

The impact of a significant reduction of emissions because of additional nuclear electricity generation can also be included, as would be needed to meet, for example, the Kyoto Accord goals. In this case, we find that the adding together of the hydrogen utilization in transportation and nuclear energy in electrification provides a leveling of the total CO2 emissions rate (see Figure 14). Given other voluntary and efficiency measures, there is clearly a fair chance of stabilizing emissions at values near to today's values. We note that this stabilization is achieved without affecting industrial energy use, which was one of the goals of this example.

With 20 CANDU reactors producing electricity for industry,

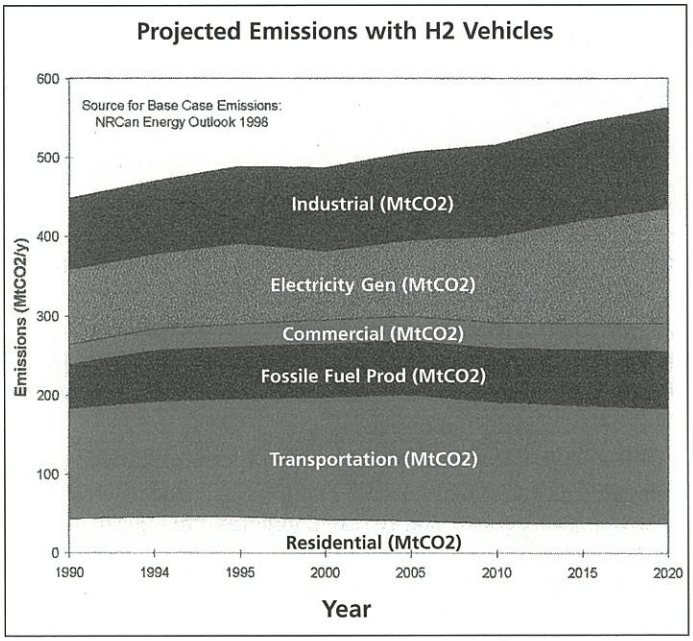


Figure 13: Hydrogen Vehicles and Projected Emissions

and as many as 20 more dedicated to transportation, the avoided CO2 emissions reductions in electricity generation and transportation are ~120Mt/y. There is no need for any restrictions on the oil and gas industries, or any others because these industries continue to fuel the base industrial and residential sectors, and the transition electricity and transportation requirements until at least 2020 to 2030. In context, this size of fleet is comparable to the present Canadian CANDU capacity.

Funding The Investment Internally: The Cost Benefit

The hypothetical zero emissions for transportation, and reduced emissions growth overall is theoretical but is based on existing technological concepts. Both the electricity generation needed and the hydrogen transportation can be designed and deployed, but at a cost. As of today, carbon dioxide emissions are freely allowed. Suggestions and approaches include taxes,

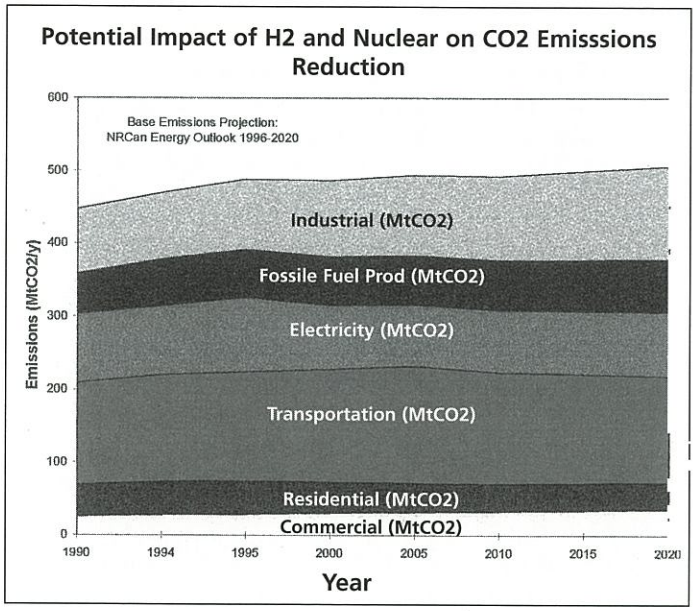


Figure 14: Potential Impact of Hydrogen and Nuclear Energy on Emissions

credits and emissions trading, all of which potentially negatively impact high-emitting nations and their economies. But we can use the concept for internal costing and cost-benefit purposes. We explore that concept to see whether hydrogen transportation coupled with non-carbon power generation is indeed internally cost-effective.

Current average Canadian light vehicle carbon dioxide emissions are ~5.3 t CO2/V/y. We assume the avoided emissions attributable to nuclear and hydrogen energy are ~3 Mt CO2/y per CANDU reactor, based on existing vehicle technology. With no additional taxes on hydrogen as a fuel, as for existing propane and methanol fuels, the operating savings to the consumer are the difference in the gasoline and hydrogen fuel charge costs. The costs for the hybrid vehicle are also greater, so we give some illustrative and comparative examples.

The average Canadian car is driven 21,000 km/year and generates on average about 5.3 tonnes of CO2 per year. That translates to abut 1.45 tonnes of carbon, or 1.72 tonnes of gasoline (based on octane C8H18) or 2400 litres of gasoline per year. At ~56 cents/l that costs $1344/year (of which about $500 is taxes). It is also a fuel consumption of 11.4 l/100 km.

The cost for hydrogen fuel as an alternate depends on the electricity cost, and our estimates are based on electrolysis using realistic efficiencies, amortized costs, and facility sizes. For distributed electrolysis, at the current retail rate of ~8 cents/kW h, the 8800 kW h it would take to run the electrolyser to generate hydrogen for a hybrid 90 mpg car would cost ~700 dollars/year for hydrogen, with no additional taxes. Actual fuel costs would thus be similar to a gasoline vehicle ex taxes. Using a local electrolyser costs about $2500 and lasts for, say, 5 years. The hybrid vehicle costs are uncertain but we assume about $5000/V based on advanced fuel cell technology (Berry, 1996). The costs for hydrogen per vehicle are thus about $2200/year. With a savings of about $1200 in taxes and gasoline for a net cost of $1000. Including the tax on the gasoline, of say $500, the total will be more like $1500 for 5 tonnes of CO2 or a cost of $300/t CO2 at the consumer level. Thus having local electricity generation for electrolysis without having to pay transmission costs, represents a significant opportunity and challenge for distributed power sources.

Alternatively, consider bulk purchase of centrally produced H2. To assess the cost of the avoided emissions, we may again proceed by assuming gasoline at 56 c/l ($2.50/g) and hydrogen at $800/t, produced by wholesale electricity (without transmission costs) at 2 to 3 c/kW h. The cost-savings to the consumer on the emissions is ~$270/t CO2,which is of similar order. If carbon emissions were indeed valued (by whatever trading, substitution or tax method is appropriate) this saving is in principle available to invest in hydrogen infrastructure.

The cost of the electricity and hydrogen electrolysis equipment are recovered in the electrical (and hence H2 fuel) cost, by the hydrogen producers/suppliers, which may be Independent Hydrogen Utilities (IHUs) The remaining costs to be funded are the costs of setting up the H2 transportation and distribution itself, and the fuel cell vehicle costs.

The infrastructure installation and penetration issue has been approached with the concept of Hydrogen Corridors, as a starting point, in high-density traffic areas, to enable a gradual start on the infrastructure.

Even at 1/5th of that price ($200/t CO2) the cost of the increased vehicle complexity is paid for internally within the vehicle actual or depreciated life of order ten years. Tax credits for H2 vehicles could also be considered as is already done for other start-up situations.

Given that the funding is within the country, there is no external (emissions trading) cost, and the capitalization for the start of a new industry is funded. The alternative of trading carbon or emissions credits to or with other countries does not allow

that flexibility for internal investment of the proceeds with any internal emissions savings.

The net cost benefit to the country of investing in non-carbon zero emissions H2 fuelled transportation systems is of order 120 Mt CO2/y times the (cost of CO2 in $/t) per year, thus totaling a benefit of order $10 to 100 B/y less the minor tax losses, which also stimulate the economy. The increased vehicle costs are of order $3 B/y, which is relatively small, and shows a superficial benefit to cost ratio of order 3 to 30 for the consumer that is entirely reasonable. However, as in any major decision, significant capital investment must be made in vehicle manufacturing, hydrogen production, and nuclear power facilities.

But as pointed out by Scott (1994-1998), the H2 currency will only be accepted and used if it is efficient and attractive, all other factors being equal. The designation of H2 use in transportation as 'green' is vital to that end, and can be endorsed only if it is matched with non-carbon H2 generation power sources, such as nuclear energy and renewables.

Conclusions

A uniquely synergistic opportunity between hydrogen, nuclear and renewable non-carbon sources of energy has emerged. This opportunity arises because it is necessary to reduce emissions without harming the economy and industry. A zero-emissions model for the total process is explored by using H2 as a fuel in transportation. To achieve the emissions reduction, a non-carbon power source must also be used.

The ability to synergistically create a market for hydrogen, fuel cells, reactors, and renewables - together with the export potential - is presented and must be considered further as a significant national business opportunity.

The H2 is derived by large-scale electrolysis, at competitive costs. Generators or suppliers, which may be Independent Hydrogen Utilities, would use the non-carbon CANDU reactor to provide the needed power and as a by-product heavy water for further plants, and excess power for exportation, as is the entire technology.

In Canada, the introduction of H2-fuelled vehicles over the next twenty or so years could lead to avoided CO2 emissions of order 120 Mt/y in the electricity generation and transportation sectors. This option is without additional taxes, mandates, or policy measures to restrict industrial or residential energy use. Thus the planned additional voluntary measures would suffice.

A national program would require of order 20 CANDU reactors producing the H2 and D2O by electrolysis, some 300 wind farms, and about 650 000 H2 fuel cell vehicles produced per year up to a total of about 13M vehicles by 2030. Nuclear energy should be regarded as an enabling technology, for H2 fuel introduction, CO2 emissions reduction, and renewables support.

The increased costs are in the vehicle equipment and the hydrogen infrastructure, the fuel costs being reclaimed by revenue by the hydrogen producers and equipment suppliers.

A cost-benefit argument can only be constructed based on avoided emissions, the lack of additional mandates, restrictions and legislation, and less potential and onerous restrictions on the industrial end-use and the energy-producing sectors.

The preceding analysis is simply one important example of how synergistic opportunities may be explored, and of innovative future approaches to electrical energy production and end-use that leverage existing and future Canadian technological capabilities.

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Improving Performance in a Competitive Environment

by R.M. White, J.J. McCarthy, W.S. Pilkington, P.D. Thompson

Ed. Note: *This paper was originally presented in the opening plenary session of the 19th CNS Annual Conference held in Toronto in October 1998.*

1. Abstract

Improving performance and sustaining improvement is not an option - it is mandatory if nuclear power is to be part of our future energy equation. The public, through the regulator, will not tolerate the increased risks associated with less than quality performance. Acceptable performance standards have been advocated by the nuclear industry for many years and the public believed that the standards were being met. However, observed indications of performance during the past several years suggest that this may not be the case.

The cultural change required to reverse the trend in Canada, to one where the nuclear industry is the leader, is a challenging task. Industry survival depends on taking prompt action leading to a sustained high standard of safety performance. This challenge comes at a time when the power industry is rapidly moving toward a deregulated environment.

Improving safety performance comes with added cost which is contrary to the cost cutting pressures associated with deregulation. How we deal with these competing forces is discussed in this paper.

2. Introduction

This paper is written from a Point Lepreau Generating Station perspective, but the authors believe the content, in general, to be indicative of the nuclear generating industry in Canada.

The history of CANDU reactors in Canada shows them to have been very successful (based on capacity factor) in the first ten years of operation. Subsequently performance is observed to degrade. Point Lepreau has operated successfully for greater than ten years, but current indications suggest an operational pattern consistent with the historical trend.

Successful operation in the early life of Point Lepreau has led to an assumption that we had an effective safety culture. Consequently corporate executives reduced operational resources, in response to deregulation forces, with a belief that operational safety performance would not be adversely affected.

This decision was taken at a time in the life of the plant when maintenance and technical challenges were increasing. The result was that the additional effort required to deal with these emerging issues exceeded the capability of available resources to do quality work within allocated times.

In retrospect the early successes of Point Lepreau did not challenge our programs and policies. Consequently we were left with a false sense of security. This only became evident when plant mid-life challenges emerged.

We now find ourselves in a situation where a major company asset is at risk. In parallel with required safety performance improvement initiatives we must:

- address emerging technical issues
- maximize work process efficiencies such that we remain competitive.

3. Urgency To Address The Issues

Increased consumption of electrical energy world wide, combined with the need to replace aging generating plants makes electrical generation a potential long term growth industry.

The nuclear option should be part of this expansion. It offers many benefits in terms of its impact on the environment, and it avoids depletion of non renewable fossil fuels which have other uses that benefit our society. An awareness of these important benefits is overshadowed by potential risks associated with the nuclear option. These concerns are amplified with any evidence that such facilities are not being operated to a sufficiently high safety standard.

If nuclear is to be part of the long term energy equation then we must demonstrate to the public that we can operate nuclear facilities such that we maintain high levels of safety performance and at the same time are cost competitive. A failure to achieve these objectives places in jeopardy:

- continued operation of existing facilities
- future nuclear development in Canada
- future offshore sales of CANDU reactors.

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1 All of the authors are associated with New Brunswick Power's Point Lepreau Generating Station

In effect, this could lead to the demise of the nuclear industry in Canada. The irony of this scenario is that in the not too distant future, the only viable option available to generate large quantities of power may be nuclear. It would be most unfortunate if Canadian developed technology had to be purchased offshore to supply our own future demands.

4. The Systematic Approach

It is unfortunate that the nuclear industry in Canada has gotten into a situation where the consequences of poor performance is the driving force behind performance improvement.

Ideally, initiatives undertaken to change or improve an existing situation should be based on an objective assessment or measure which can be linked to a:

- program deficiency
- station goal or objective.

We should not be in a position where the consequences of poor performance are the motivators which establish the need and set the agenda for a performance improvement program.

Given the current state of safety performance in the nuclear industry, we must take immediate steps to correct obvious problems. In parallel, we must establish a strategic planning process which is based on a systematic approach - one where we have established goalsand targets consistent with the station mission.

A failure to take this approach makes it difficult to determine whether any proposed program is appropriate to address the real problem(s). The systematic approach involves the following elements:

- a detailed analysis of observed events to determine the underlying causes (a fundamental issue)
- identification of projects required to correct the problem(s)
- a plan of action which defines the project end goal
- resourcing
- implementation
- measurement to ensure that scheduled plan milestones are being achieved, and that the end goal has been reached
- on-going assessment to ensure that achievements are being sustained, with a follow-up process to address unsatisfactory findings.

5. The Point Lepreau Approach to Performance Improvement

The Point Lepreau Generating Station operated very successfully from its commercial operational date in February 1983 to the start of an extended planned outage in 1995. Throughout this time, relations with the regulator were good, but in recent years there has been increasing evidence that they were becoming concerned with increasing station work backlogs.

We completed the extended 1995 outage on schedule and under budget. This apparent success left us with a feeling of confidence and optimism that past trend-setting capacity factors would continue into the future.

Corporate NB Power, in the background, were aggressively looking at ways to improve efficiency to better position the utility in a deregulated environment. The Point Lepreau success picture did not portray the station to be an aging plant, requiring additional resources to deal with emerging maintenance requirements and corresponding longer plant outages. Consequently, little sympathy could be garnered for any proposal involving increased resources for Point Lepreau.

Our confidence and optimism from the apparent success of the 1995 outage was short lived. On start-up, the shaft on a main Primary Heat Transport pump was sheared as the result of mistakenly leaving a wooden cover in the PHT system. The cover was shredded and spread throughout the PHT system with recovery extending the outage by approximately three months. Within the next year, additional deficiencies originating from work initiatives undertaken during the 1995 outage, were discovered. As a consequence of these failings the regulator applied a condition to the station operating Licence. The condition required semi-annual reporting to the regulator on the implementation and evaluation of measures, programs or initiatives developed for the purpose of promoting safety in work practices and processes at the facility.

We were aware of, and had commenced implementation of, safety performance initiatives at the station. However, the input from the regulator prompted us to accelerate and better formalize our improvement program plans.

Initially we took action to correct known deficiencies, identified by our own internal assessment and issues that were identified by WANO as being areas for improvement. We continued to progress initiatives in this informal way until May of 1997. In parallel, we scoped out a three phased systematic approach to deal with all issues necessary to improve safety performance at Point Lepreau. This approach is:

- phase one (Oct 96 - Aug 98) - progress initiatives to correct identified deficiencies. In parallel develop and implement a plan to address all required performance improvement initiatives and progress the development of a strategic long term planning process.
- phase two (Sept 98 - Dec 2000) - complete performance improvement initiatives to an extent that they become integrated into the way the station does business on an ongoing basis. Commence implementation of strategic planning such that at the end of this time period, necessary effective programs are in place and being monitored and acted upon, on the basis of goals, measures and targets. It is through this process (strategic planning) that the required level of safety performance will be maintained on an ongoing basis. This final step, full implementation of strategic planning, is really the commencement of phase three.
- sustain a high standard of safety performance on an ongoing basis through implementation of the long term strategic plan.

In developing our overall performance improvement program we identified in excess of 40 projects. These projects were identified based on the following:

- our own internal review

- recommendations for improvement from a full peer assessment by WANO
- Regulator staff observations

Our plan involved the establishment of a performance improvement group to budget, plan, schedule, monitor, initiate corrective action as appropriate, and report progress every two weeks. The actual work required to implement the various projects is the responsibility of the line organization. Each project has an assigned member of the line organization responsible to progress the project such that schedule milestones are achieved.

A steering committee comprising senior corporate staff members, the performance improvement group leader, and the station line managers (including the station manager) meet on a two week frequency to address any problems, establish new or reinforce existing priorities, ensure line organization=s continued commitment to priority projects and to ensure continued corporate focus.

We initially attempted to address all projects, only being limited by the availability of qualified staff. We took this rigorous approach realizing that it was a commitment to the regulator.

In April of 1997 we made our first conditional presentation to the regulator. The presentation outlined our strategy, implying that it was our intent to progress most performance initiatives simultaneously.

The effort required to progress many fronts quickly became a concern. Equally, we were concerned that our program was not independently verified.

In June of 1997 we had WANO do an independent assessment of our problems to verify the adequacy and scope of our proposed improvement program. The assessment involved a review of recent unplanned events, and a series of one-on-one and group interviews with staff from all station work groups. They concluded that our proposed improvement program would address our performance problems. However, they cautioned us that success would be unlikely unless we narrowed our focus to several key initiatives.

Concurrently, a second group of external advisors (a group of three senior executives commissioned by our president to provide independent advice on our approach and the likely expectations of a regulator) also recommended that success would be greatly enhanced if we limited our focus to less than five issues.

The feedback from both of the above groups prompted us to act immediately. From an earlier assessment of unplanned events, we determined that human performance was the most common unplanned event causal factor. Greater than 50% of the events examined had some element of human failure. This is consistent with findings documented in other published reports. This finding prompted our decision to focus our program on three human performance initiatives:

- Conduct of work
- Safety awareness
- Supervisory effectiveness

Other projects were continued in the background, but not at the expense of progressing projects supporting the focal issues.

At this point, we also felt that an independent verification would be useful to confirm:

- our selected focal issues
- The effectiveness of our new systematic event investigation process (TapRooT7)

A second experienced WANO team did an independent assessment of recent station unplanned events, using a different systematic process (HPES). They confirmed that human performance failings were a significant contributor to station unplanned events, and gave us confidence that our new event investigation process was effective.

Focusing on these issues involved developing documentation, promotional campaigns, and extensive staff training followed by evaluation to assure that the desired effect was achieved.

At this point in time, we have completed the project phase for six of the seven focal projects. Significant progress has been made in the remaining area, but work continues in the development of the supervisor training program. We believe that safety performance has improved, but we need to accelerate the pace of change.

The strategy for the next two years is to maintain our focus on human performance, while at the same time broadening our focus to include the next most important areas requiring improvement. Following the development of selection criteria, we selected 17 projects. These were then categorized into four focal areas of which 10 projects were designated Category A (the highest priority), while the remaining 7 were assigned to group B.

The focal areas for the group A projects are; Supervisory effectiveness, Work Management & Control, Plant Ageing, and Sustaining Improvement. The Work management & Control area is made up of number of separate projects. These include; introducing a forward scheduling process, improvements to the Work Permit process, reducing maintenance backlogs, reducing the backlog of outstanding corrective actions, reducing the backlog of outstanding AECB Action Items, introducing a Problem Identification and Corrective Action (PICA) process, and introducing a work management system for technical work. The focal area on sustaining performance was also subdivided into two projects. These are; complete the development of a strategic plan, and the introduction of a Self-Assessment Program.

The group B projects include; OP&P improvements to reduce non compliances, introduction of a Safety Culture refresher program, improvements to the design change and configuration management processes, Procedure improvement program, introducing a comprehensive training program for all work groups, and the development and implementation of a staffing and succession plan.

6. Lessons Learned

The performance improvement program is the most important and comprehensive program undertaken at Point Lepreau. Aspects which make the program unique include:

- historically our focus had always been on technical issues, while human performance issues were viewed with a much lower priority
- the program involves a significant increase in resources (100+) over a long time period (>5 years)
- we perceive pressure from WANO and the regulator to show positive results in a timely manner
- it involves significant changes to work processes and staff practices
- it was initiated in parallel with our attempt to address a large backlog of work

We initially approached our performance improvement program much like any technical project. We did not anticipate the many non-technical problems that surfaced. These new challenges are providing us the opportunity to learn more about the human side of the business. We need to address future human problems as adeptly as we address technical problems. We have responded to this by obtaining significant assistance from Corporate Human Resources Specialists.

The more significant problems we encountered, and other observed areas which we believe to be potential problem areas are discussed below. It is our hope that this discussion will help others embarking on a similar program, to be more aware of non-technical problems during the planning stage of the program.

Line management and staff's reluctance to change - performance improvement means changes to programs, standards, and priorities, as well as staff re-assignment. Work groups felt that the additional work load was counterproductive at a time when backlogs were already at an all time high and continuing to increase. Staff were already overworked from dealing with a series of planned and unplanned outages and other issues identified by station management as high priority jobs. Overcoming this reluctance to change must be countered by senior management continually emphasizing the need for, and demonstrating their commitment to, a performance improvement program.

Staff skepticism about management's commitment to performance improvement - staff were aware of identified problems and process deficiencies that existed for years, which management had failed to address. Management saying they will fix the problems is not enough. Before they are convinced, the line organization must see change which actually affects the way in which they do their jobs.

Communication - Sending memos, or relying on middle management to communicate was not effective. Since success must be achieved through first line supervision, senior management must personally transmit the message frequently, clearly, and precisely to them. The first message to be communicated is the need for change and the urgency with which it must occur.

Limiting the focus of an improvement program - An overall improvement program may involve initiatives in many areas, but attempting to promote more than two to five issues simultaneously reduces the probability of the program being effective.

Relating issues to the workers job - different techniques can be used to promote performance initiatives, but for them to be fully effective, there is a need to show, through example, a correlation between the initiative being promoted and the workers' job responsibilities.

The application of a systematic approach - a performance improvement program should be based on a systematic approach. This will establish credibility. It will also meet the ongoing challenge of demonstrating that the program is leading to the target standard of performance. A systematic approach will also ensure that the improved performance will be sustainable.

The program content should address root problems which are determined through an analytical process. The program should then be implemented to direct the station work force toward the targets and to establish performances measures for monitoring results on an ongoing basis.

Verification of the improvement program - a second review, particularly by an external body is necessary to provide an added level of assurance that the process is correct and to increase its credibility.

Exposure of staff to facilities where other work methods are effectively employed - in many instances staff have never seen a process other then the one that is currently being employed by the station. An aging work force that has never been exposed to other methods tend to have a mind set that there is no alternative to their processes and hence are reluctant to give a new method or process a chance. Having staff visit facilities with different processes or methods is an effective way to acquire work group acceptance.

Organization structure and accountabilities - the structure of an organization or lack of clear lines of authority and accountabilities for each division may be a mitigating factor to success. Failing to address such an issue at the outset increases the risk of failure or as a minimum will delay success.

Leadership and Core Values - senior management must adopt and continually demonstrate core values of sincerity, honesty, fairness, caring, integrity etc.

Expectations and Standards - workers can only be effective if they know what is expected and the standards to which work must be done. This is one of the fundamental building blocks to success.

Performance Improvement and Line Management Meetings - where implementation of performance improvement plans are the responsibility of the line organization, it is essential that regular meetings be held to ensure that schedules and priorities are maintained. A failure to reinforce the focal project areas leaves open the possibility for emerging station issues to displace resources from the focal projects.

The Scope of Performance Improvement Programs - a substantial amount of additional work results from an improvement program. This additional work must be integrated into other necessary ongoing station activities. How all necessary station objectives can be practically met must be presented in a comprehensive plan.

Acquiring additional staff - the increased work load associated with a performance improvement program typically involves acquiring additional resources. New resources will not be fully capable of productive work soon after arriving on site. It typically takes months or sometimes years before employees can be fully effective. An influx of new resources can represent an ini-

tial setback to progress, as existing staff are required to assist with the development of new staff.

7. Counter Measures to Promote Maintaining A Competitive Edge

Taking the initiative to deal with safety performance problems is not a one time effort. Established goals must be achieved and gains realized must be sustained on an ongoing basis if we are to maintain public confidence in the industry. We must also realize that there are significant costs associated with achieving and sustaining a high safety performance standard. Recent trends suggest that rising safety performance standards will tend to increase costs.

At Point Lepreau the estimated cost for the next 2 years to achieve our target performance level is expected to increase the station OM&A budget by greater than 20%. An ongoing incremental cost of 10% is expected to sustain the required level of performance.

Known added costs and uncertainty for potential future costs of rising safety performance standards are gradually making alternate energy sources an attractive option. The intangible benefits of electrical energy from nuclear generating facilities are not being effectively communicated to society at large. Examples of such benefits include:

i) minimal impact on the environment
ii) alternate fuel sources are non-renewable and have other applications which benefit society
iii) fuel transportation costs are low and indirect costs are lower than for alternate fuels.

If we do not take measures to counter the increasing cost of operating nuclear power facilities, there is a real risk that our industry will be displaced with other alternatives which have a significant negative environmental impact.

We must meet high levels of safety performance but we must do it in a cost effective manner. In fact we need to look at all aspects of our operation to eliminate unnecessary cost. Furthermore we need to examine all future suggestions or recommendations promoting the increase of a safety performance standard. We must be prepared to challenge when it can be demonstrated that the costs do not justify a marginal gain in safety performance, if the risk is already extremely low.

Some of the areas that need to be examined to ensure that costs are controlled on an ongoing basis, are discussed below.

Organizational Structure - establish station goals and objectives; then assess each level within the organization and make necessary changes such that business can be conducted efficiently. The organization should be restructured to remove redundant layers and, where appropriate, sub-divide work groups to remove bottlenecks within the organization.

Work Processes - Examine all work processes to ensure that each is streamlined, and remove unnecessary steps. In parallel, look at other organizations to see if there are more cost-effective processes that could be useful to your organization.

Staff Training - in addition to the safety performance concerns, identify staff training deficiencies which are resulting in higher resource cost and poor quality of work. Such deficiencies increase rework, and reduce overall station reliability. We must be assured on an ongoing basis that staff possess the required competencies to meet high standards with respect to safety, quality and efficiency.

Managing the work force - as a first step in managing workers, management and supervision need to document and make known worker expectations and standards. They then need to observe compliance, and reinforce expectations through ongoing communication. These basic steps are necessary to ensure that quality standards are being met and that acceptable levels of productivity are achieved.

Maintenance - look for opportunities to perform more on-line maintenance, to reduce both planned and unplanned unit outages and, for possible opportunities to reduce the frequency of preventive maintenance.

The development and implementation of an aging program which recognizes ongoing equipment degradation provides the opportunity to properly plan for the repair or replacement of equipment before it results in an unplanned outage.

Performance measures - look for ways to measure the effectiveness of all programs and processes. Such information is necessary for control of the process and to provide management with the information necessary to set goals and make informed decisions.

Work place Self Assessment - implement a station self assessment program, one where people at the working level participate in the assessment of their work group practices, and where they have the opportunity to provide input to any corrective action decision. Worker involvement provides a higher degree of assurance that change will be accepted without undue challenges.

Inform the public - implement programs to better inform the public about the positive benefits of nuclear power. Appreciation of the real facts should promote a higher level of acceptance and less pressure to increase the standards when the risk are negligible.

Challenge unnecessarily restrictive standards - take the initiative to challenge suggestions of increased standards when the cost versus the benefits are unreasonable.

8. Conclusion

As operators of nuclear facilities we must be responsible and take initiative to address all issues which are not in accordance with high safety performance standards. At the same time we have to be prepared to defend against pressures to initiate improvement when safety margins are already high, and significant costs would be required for marginal improvement.

We need to continually advocate the benefits of nuclear power versus alternate sources of energy. Currently the nuclear option offers a significant cost benefit over the alternatives. This advantage is gradually decreasing due to the emergence of new technical problems consistent with the aging process, and the trend to continually increase safety performance standards. To prepare for the deregulated environment, and to counter other issues we are unable to control, we need to be vigilant in looking for and implementing new initiatives which will improve efficiency within any part of our organization.

Replacement Divider Plate Performance Under LOCA Loading

by Hong M. Huynh[1], G.H. McClellan, W.G. Schneider[2]

Ed. Note: *This paper was originally presented at the CNS Maintenance Conference in the fall of 1997, under the title, Replacement Divider Plate Performance Under LOCA Loading, but is still relevant. Divider plates of the design described have now been installed in the steam generators of the Gentilly 2, Point Lepreau and Embalse nuclear generating stations, all of which are of the CANDU 6 design.*

Abstract

A primary divider plate in a nuclear steam generator is required to perform its partitioning function with a minimum of cross leakage, without degradation in operating performance and without loss of structural integrity resulting from normal and accident loading. The design of the replacement divider plate for normal operating conditions is discussed in some detail in reference 1 and 2. This paper describes the structural response of the replacement divider plate to the severe loading resulting from a burst primary pipe. The loads for which the divider plate structural performance must be evaluated are mild to severe differential pressure transients resulting from several postulated sizes and types of pipe break scenarios. In the unlikely event of a severe Loss of Coolant Accident(LOCA) the divider plate or parts thereof must not exit the steam generator nor completely block the outlet nozzle. For the milder LOCA loads, the integrity of the divider plate and seat bars must be maintained. Analysis for the milder LOCA loads was carried out employing a conservative approach which ignores the actual interaction between the structure and the primary fluid. For these load cases it was shown that the divider plate does not become disengaged from the seat bars. For the more severe pipe breaks, the thermal-hydraulic analysis was coupled iteratively with the structural analysis, thereby taking into account divider plate deformation, in order to obtain a better prediction of the behaviour of the divider plate. In this manner substantial reduction in divider plate response to the more severe LOCA the loading on the divider plate was achieved. It has been shown that, for the case of a postulated Large LOCA(100 % reactor inlet header) ,the disengagement of the divider plate from the seat bars results in less than 1% opening of the divider plate area.

1.0 Introduction

The primary divider plate in a nuclear steam generator performs the function of diverting the reactor outlet D2O flow up through the U-tube bundle thereby cooling it before its return to the reactor. This function is therefore of prime importance in transferring the heat removed from the fuel in the reactor core to the steam generator secondary side thereby generating steam. In carrying-out these functions the divider plate is normally subjected to an operating pressure load equal to that of the pressure drop through the U-tubes of approximately 35 PSI. To accommodate this operating load with sufficient margin, the divider plate is designed for a static pressure drop of 60 PSI. The design method is discussed in the papers of references 1 and 2.

Well into the design and manufacture of the lead replacement divider plates for Hydro Quebec, additional design requirements were identified by the Gentilly 2 Safety Analysis Group. The new requirements stipulated that in the unlikely event of a burst primary pipe accident (LOCA), the divider plate must not generate loose parts that could exit the steam generator nor must it completely block the outlet nozzle. For the smaller LOCA events the integrity of the divider plate and seat bars must be maintained.

The discussion that follows briefly reviews the unique design features of the replacement divider plate and describes in some detail the method of analysis developed to evaluate the replacement divider plate behaviour under LOCA loads.

2.0 Features of the Replacement Divider Plate

The replacement divider plate is a strong, lightweight, integral construction designed for ease of installation and minimum by-pass leakage. The features included in the design of the replacement divider plate were primarily intended to reduce leakage and thereby lower the temperature of the reactor inlet header (RIH). Because the design is a single piece, the flow leakage crevice area is much smaller than the original design.

1 Hydro Quebec, Montreal, Quebec, Canada
2 Nuclear Engineering, Babcock & Wilcox, A Mcdermott Company, Cambridge, Ontario, Canada

The only leak path is around the periphery of the divider plate at the tongue and groove joint (See Figure 1). Erosion resistant material is employed at these sliding joints to ensure that leakage rates do not increase with time.

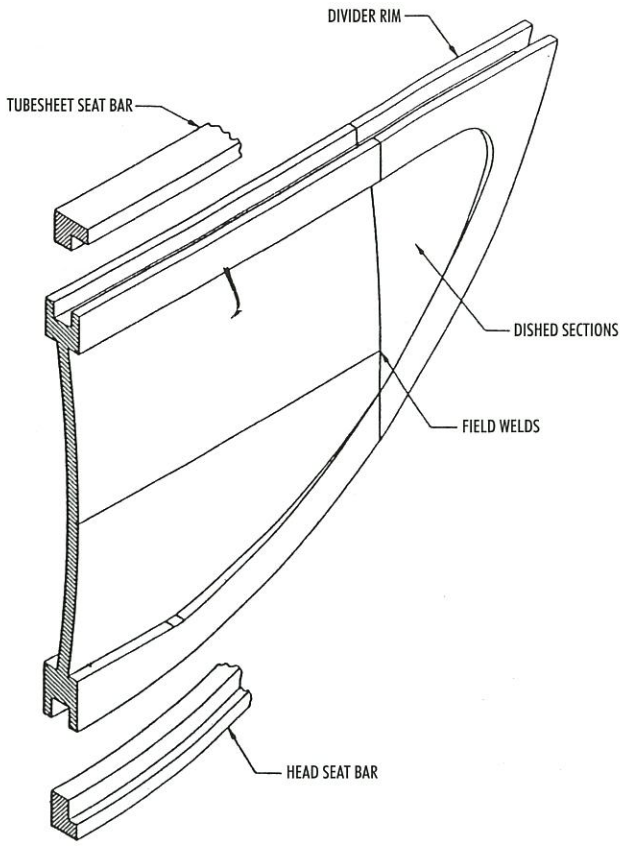

Figure 1: Welded Floating Divider Plate

The original primary divider plate was a segmented design 1-1/2 inches thick (See Figure 2). The replacement divider plate is only 3/4 inches thick. It has been curved in order to provide the necessary strength thereby providing a relatively lighter weight for ease of installation, minimizing weld volume (and radiation exposure to welders) and minimum distortion due to welding that could result in binding of the divider plate on the seat bars. The design has been patented by B&W(3).

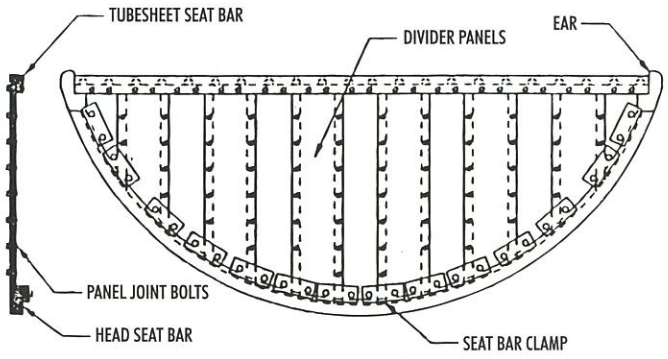

Figure 2: Segmented Divider Plate

3.0 Dynamic Analysis for LOCA Loading

(i) LOCA Loads

The original divider plate transient differential pressure loads were computed by Hydro-Quebec Safety Analysis Group by employing the thermal-hydraulic Code SOPHT-G2 version 03.02. These loads do not take into account divider plate deformation. Several LOCA loads were eventually identified. These transient loads are shown in Figure 3 through 6. As can be seen, some of the loads are clearly much more severe than the loading for which the replacement divider plate was originally designed. (Note: these pressure-time curves hereafter are referred to as original pressure versus time curves)

(ii) Preliminary Structural Analysis

Initially a non-linear transient dynamic analysis utilizing ABAQUS EXPLICIT Version 5.5 was carried out to determine the sensitivity of the divider plate response to variations in the assumed friction factor at the tongue and groove joint and to confirm earlier dynamic analysis carried out by Ontario Hydro. The response of the divider plate for friction factors from 0.2 to 1.2 was studied. It was hoped that a defendable friction factor would result in a significant reduction in the response of the divider plate to the dynamic loads. For simplicity, the preliminary structural analyses were carried out conservatively assuming that the thermal-hydraulic solution and the structural solution do not affect each other.

Initially three load cases were considered, 5%, 7-1/2 % RIH Breaks and a 100 % Pump Suction. A sensitivity study was also performed to examine the effect of the friction factor. The effect of the friction factor from 0.2 to 1.2 was evaluated. This sensitivity study indicated that the increased friction factor will tend to reduce the rate of deformation of the divider plate for a given differential pressure load transient.

Mixed results were obtained in the aforementioned analyses (See section 4.0) and it became clear that if realistic results were to be obtained for the more severe load cases it would be necessary to allow for the effects of the deformation of the divider plate.

In the initial dynamic analysis two important effects that tend to reduce the response of the divider plate were conservatively ignored. These are, bypass leakage resulting from the open area formed when the divider plate starts to disengage and back-pressure reduction resulting from the deforming divider plate pushing primary fluid out of the steam generator outlet nozzle.

To take these effects into account, and thereby effectively reduce the load on the divider plate, requires that the thermal-hydraulic solution be 'coupled' with the structural solution. To achieve this, an iterative procedure was developed that manually links the Hydro-Quebec thermal- hydraulic analysis with the B&W structural analysis. How this 'coupling' is achieved is included in the discussion that follows.

(iii) Thermal-Hydraulic and Structural Coupling

The thermal-hydraulic analysis (HQ) is manually linked with the structural analysis (B&W) as shown in Figure 7. An original

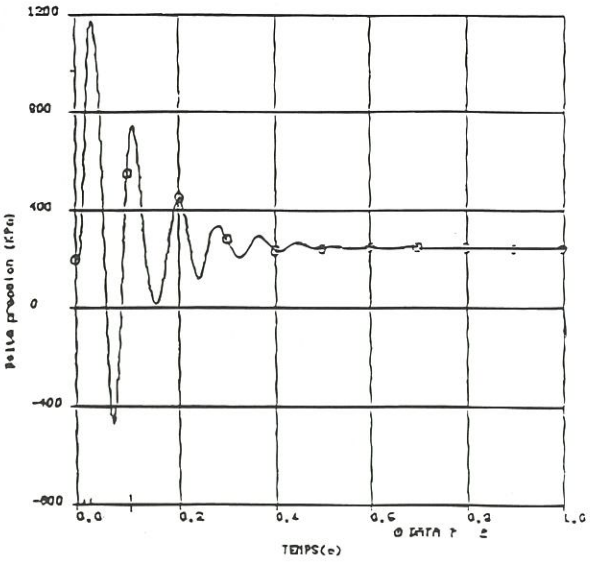

Figure 3: Divider Plate Loading – 5% Equivalent RIH Break.

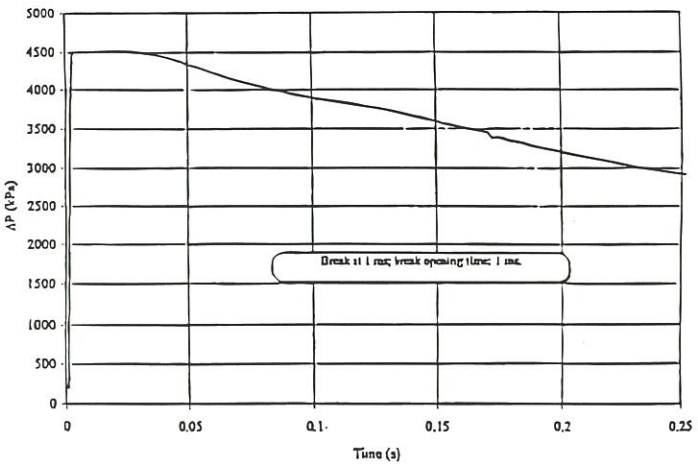

Figure 5: Divider Plate Loading – 100% Pump Suction Break.

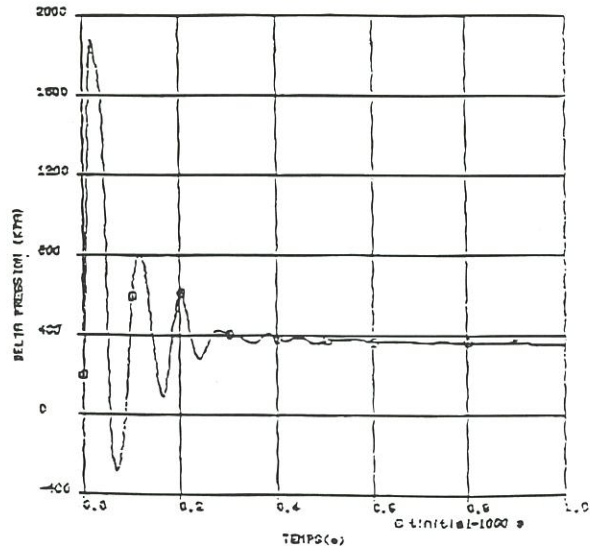

Figure 4: Divider Plate Loading – 7.5% Equivalent RIH Break.

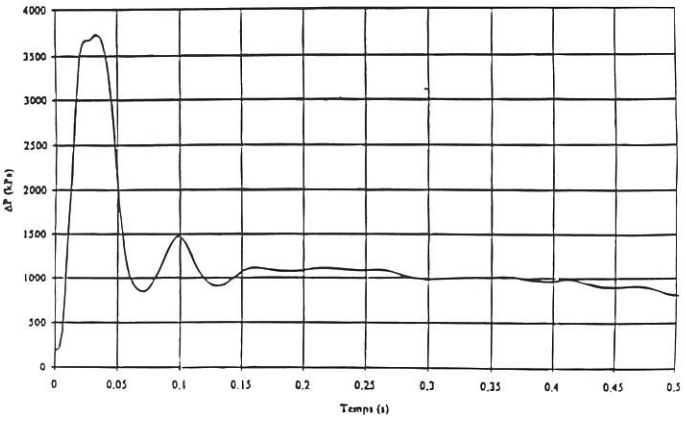

Figure 6: Divider Plate Loading – 100% RIH Break.

pressure versus time curve (P-T) for the first iteration was run for an interval from to to a suitable time t1 at which time a certain amount of displaced primary fluid volume, resulting from divider plate deformation, is reached. The volume reduction of the outlet side as a function of time for this interval was provided to HQ for input into the thermal hydraulic analysis.

The thermal hydraulic analysis was re-run for the same time interval taking into account the displaced volume function and a new pressure versus time load curve computed for the interval. A check is made to determine if the P-T curve has converged by comparing it to the prior curve. If it has not converged the displaced volume versus time curve is recomputed based on the current structural run and the procedure repeated until convergence of two serial P-T curves is achieved.

At some point in time, for the more severe loads, the tubesheet seat bar and divider plate start to disengage and a by-pass leakage flow results. This by-pass flow will tend to reduce the response of the divider plate still further so it too is included in the iteration procedure in a similar manner to the displaced volume. Figure 7 illustrates how this is incorporated.

The above procedure was employed to analyse divider plate response to the 100 % RIH Break. This load case (original load) is shown in Figures 8. Again, these original loads had been determined based on the assumption that the divider plate remains in-place without any deformation and does not by-pass primary fluid.

4.0 Discussion of Results and Conclusion

The results of the initial conservative analysis for the 5% and 7-1/2 % RIH breaks indicate that the divider plate remains fully engaged with the seat bars on both the primary head and tubesheet. For the 100% Pump Suction Break the divider plate completely disengaged. However owing to its construction details, it can not exit the primary head to form a loose part.

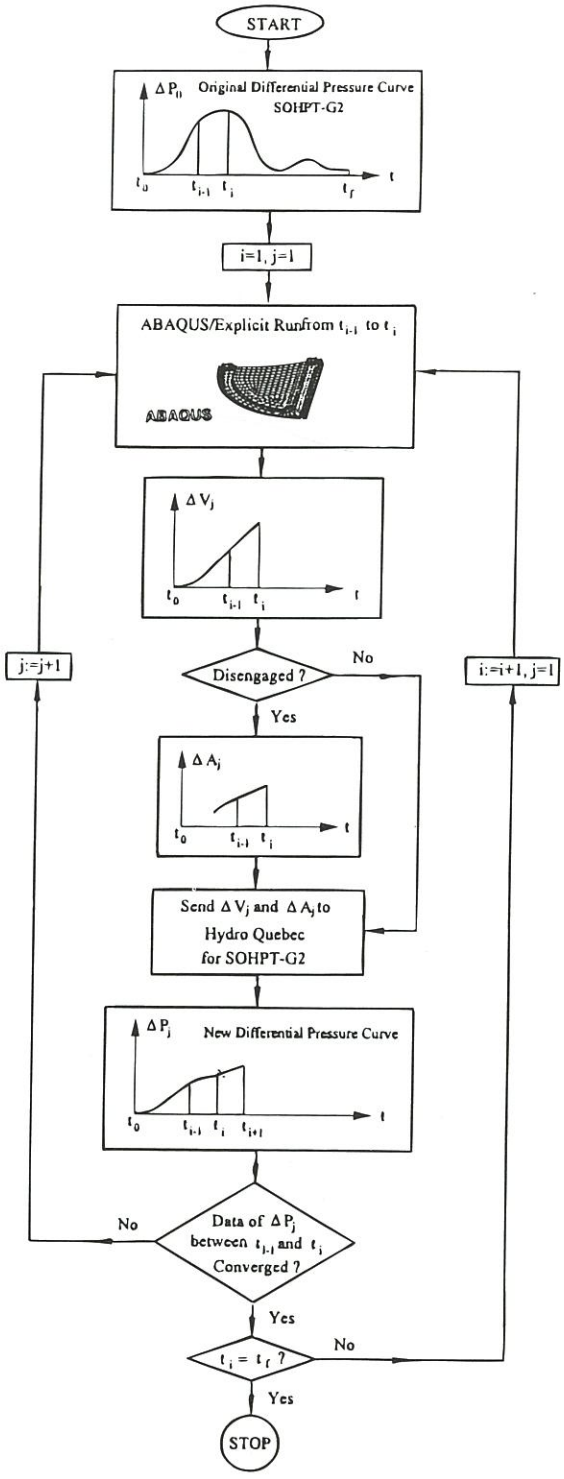

Figure 7: Flow Chart of the Analysis.

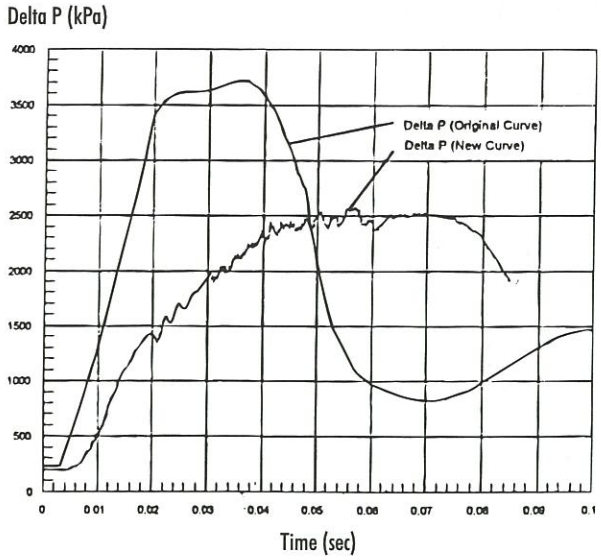

Figure 8: Comparison of the One-Step Analysis and the Iterative Analysis.

With such a high load, seat bar weld failure was a very significant concern. If the seat bars weld fails, the seat bar becomes a loose part since it can easily exit the primary head of the steam generator. The seat bar weld strains were shown to be acceptable thus precluding the loose parts concern. This conclusion can be broadened because the loading employed is conservative as discussed below. We can conclude that even for the most severe loading, the seat bar welds will not fail and therefore the seat bars will not become loose parts.

Even though the LOCA requirements were not considered when setting the replacement divider plate design, the curved divider plate concept appears to be fortuitous in dealing with the large deformations that result from the more severe LOCA loads. Because the design is curved, it can deflect more than 4 inches under the severe LOCA loading without significantly reducing the engagement of the divider plate on the seat bars. Considerably more deflection is required in order to cause the complete disengagement of the divider plate from the seat bars. This large deflection results in considerable load reduction owing to the relatively large volume of primary fluid that must be displaced out the primary outlet nozzle by the deforming divider plate and the increase in available volume on the primary inlet side of the steam generator. Furthermore, the significant by-pass flow area that opens up before the divider plate becomes entirely disengaged from the seat bars also tends to reduce the LOCA loading.

The aforementioned means of reducing the response of the divider plate that were not included in the initial analysis have a very significant beneficial effect that results in considerably less divider plate deformation. Figure 8 shows the 100 % RIH LOCA with and without taking into account the deformation of the divider plate. As indicated, the maximum pressure load is much less severe when the deformation of the divider plate was modelled. This, in effect, shows the load reductions achieved by the iteration technique developed to 'couple' the thermal-

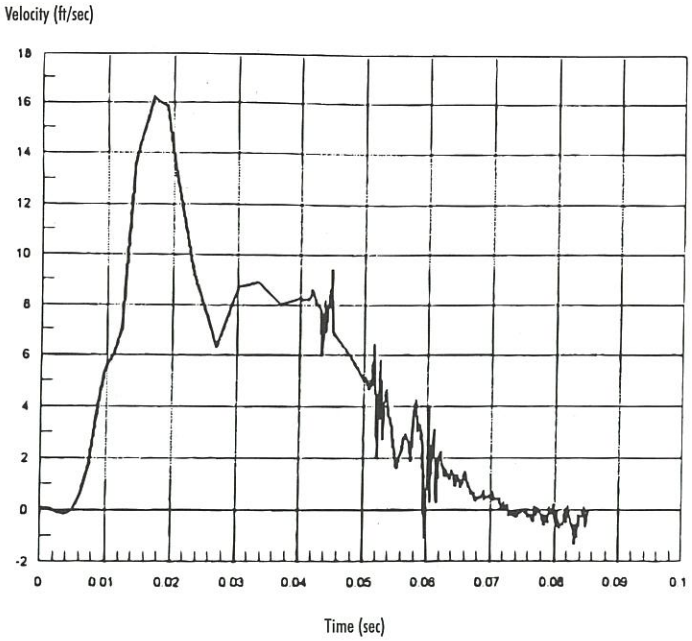

Figure 9: Maximum Velocity of the Divider Plate.

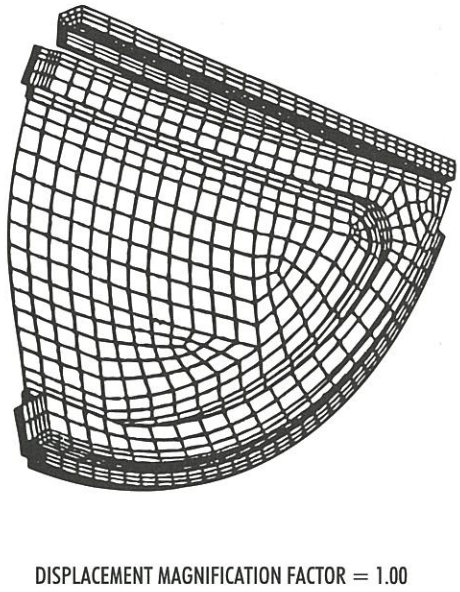

Figure 10: Deformation of the Divider Plate for 100% RIH Break (t = 80 msecs).

hydraulic and structural solutions. Figure 9 shows the maximum velocity of the divider plate. As can be seen the divider plate has come to a stop and has started to return to its original reached a steady state position.

The results confirm that for the 100% RIH break (Figure 6) the divider plate only slightly disengages with the tubesheet seat bar (approx. 1% of open the divider plate area). Figure 10 shows the deformed shape at t = 80 msec. Deformation is shown with a magnification factor of 1.0..

5.0 References

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2. Gentilly-2 Divider Plate Replacement- J. Forest, E.Kiisel, G.McClellan, W.Schneider. Canadian Nuclear Society, Third International Conference on CANDU Maintenance, November 21,1995
3. U.S. Patent No. 5,623,763, Method of Replacing a Primary Divider Plate in a Steam Generator, Inventors: H.G.McClellan and W.G.Schneider

7.0 Acknowledgements

The authors would like to acknowledge the contributions of C. Hasnoui and K. Joober at Hydro-QuJbec to perform the SOPHT-G2 runs and Yanghu Mou (B&W) and R. Sullivan at Backock & Wilcox to perform the ABAQUS runs.

The Future of Point Lepreau Nuclear Generating Station

Public Hearings on Electricity in New Brunswick

by Neil Craik

Ed. Note: *Neil Craik, a long-time member of the CNS now living in Fredericton, N.B., followed closely the hearings of the N.B. Select Committee on Energy as it studied the Future of the Electricity Industry in New Brunswick and appeared before the Committee in November 1998. Following is a slightly edited version of his report.*

Over the period November 1998 to March 1999 the Select Committee on Energy of the Legislative Assembly of New Brunswick held public hearings across New Brunswick on the future of the electricity industry in New Brunswick including. The issues covered were:

- the future of NB Power in a deregulated environment
- public vs. private ownership
- monopoly vs. competitive Market
- integrated vs. segmented Industry
- ensuring competitive rates, stable and reliable service and security of supply
- the future of the Point Lepreau Nuclear Generating Station
- the impact of natural gas on the electricity industry

The public hearings were completed on March 23 and the Select Committee is expected to submit its report to the Legislature at the end of April, 1999.

Preparation for these hearings began in February, 1998 when the Government of New Brunswick issued a discussion document and commissioned a task force to consult privately with some 42 "stake holders". A report by David Hay a Financial Services Advisor and Donald Savoie of the Universite de Moncton was published in July 1998.

This article only deals with presentations made on Point Lepreau NGS and the environmental aspects of natural gas.

Since NB Power has a variety of generating stations including hydro, heavy fuel oil, light fuel oil used in gas turbine generators, local coal, imported coal, orimulsion and nuclear it is notable that Point Lepreau NGS had special mention in the scope of these hearings.

As a personal observation, these hearings have been a demonstration of democracy in action, with it strengths and weaknesses. Written briefs could be submitted and anybody could request to make a verbal half hour presentation plus. However some large companies were given a couple of hours. About 40 public presentations were made.

Only the Select Committee could ask questions, so it was possible for a presenter to make questionable statements without immediate intervention by a knowledgeable member of the attending public.

Dr. Myron Gordon, a Professor Emeritus of Finance at the University of Toronto, gave the most credible presentation on the on perils of privatization of electrical utilities. Following are extracts from his submission on the assessment of the value to NB Power of the Point Lepreau NGS, with some subsequent comments by the writer.

(Extract from Prof. Gordon's presentation.)

Background

The calls for the privatization and deregulation of NBP power have been fuelled by its losses over the past four years. The losses are due primarily to operating problems at the Point Lepreau Generating Station (PLGS). Should PLGS be retired or refurbished, that is, rebuilt to serve another 20 or more years? Should it remain under government ownership or be privatized?

PLGS was built with the expectation that its 680 MW of capacity would operate for 30 years at 80% of capacity. The engineering economic calculations made before the PLGS was built established that with this life-capacity factor, the station would be the most economical source of power for NBP by a wide margin. In other words, it would be immensely profitable. Over the first 12 years of operation, that is 1983-4 through 1994-5, the PLGS operated very close to capacity, well over 90% in many years, and invariably ranked first or second in the world in capacity utilization. Over this period profitability was even greater than the original high expectations for it.

However, unfortunate developments emerged over the next four years and staffing had not been maintained at the required levels. In 1995-6, PLGS operated at only 29% of capacity, and in the next two years output rose to only 63% and 67% of capacity.

The other problem at PLGS [is] that [it] will have to be shut down prior to the end of its expected 30 year life, due to premature failure of its pressure tubes. The best estimate now of the PLGS's life is 25 years.

Profitability of Point Lepreau Generating Station

Notwithstanding the above problems, the operating performance and profitability of PLGS have not been reduced materially. The original forecast for lifetime operation was 210,000 hours, based on 80% capacity utilization over a 30-year life. Utilization has been low during the last three years and the life has been reduced to 25 years. Nonetheless, lifetime utilization is now likely to be 187,000 hours, down only 11% from the original forecast. This figure is based on the outstanding performance during the first 12 years, the poor performance during the next three years, and an 85% capacity utilization in the current and next nine years.

The PLGS was exceptionally profitable during the first twelve years of its operation. The high capacity utilization enabled NBP to earn a profit of over $500 million during these twelve years. In addition, the the price [of electricity], adjusted for the rise in the general price level, fell sharply over these years. These were years in which most electric power companies in North America had sharply increased rates to consumers and sharply reduced profits to owners due to the rise in costs.

Over the last four years, NBP had losses of $200 million [which falls] far short of eating up all the gains of the previous eleven years. Furthermore, during these four years, the nominal price of electricity charged to in-province customers increased by only 8.8% from 5.79¢ to 6.30¢. The annual rate of increase was about the same as it had been over the prior 5 years.

Future Prospects

The President of NBP predicts that it will turn a profit in the year ending 1999 March 31. If PLGS continues operating at capacity over the remainder of this year, the profit will be big. The profit picture over the next nine years is exceptionally bright under the assumption that PLGS will operate at 85% of capacity over these years.

This is a reasonable assumption because there is considerable evidence that NBP has restored excellence to the operation of PLGS. Over the last two years, NBP has increased employment by 100 workers at PLGS and has operated at capacity for the last six months.

NBP will need $1 billion around 2008 to extend the life of PLGS another 20 years, should it decide to do so. With 85% capacity utilization and with other favourable developments, it is very likely that NBP will be able to generate internally that billion dollars. The internal sources of funds will include the reduction in purchased power and fuel cost made possible by operating PLGS at 85% of capacity.

This rosy forecast is by no means certain, but it represents what is most likely to happen. NBP will then be in an exceptionally strong financial position. With its debt no higher than its current level and its equity up substantially, the debt ratio should fall to 75% from 89% at the end of 1997-98.

The very important decision that NBP will face within a few years is whether to retire or to refurbish; that is rebuild PLGS so that it can operate for another 20 years. Under the conservative assumption that it would operate at 80% of capacity, it would produce 4,700 million kwh of electricity per year.

The President of NBP, has stated that the PLGS has a 1.7¢ per kwh cost advantage over the best alternate source of power. Combining the above production and cost advantage produces an increased profit through cost saving of over $81 million per year. The immense profitability of PLGS's current operation and of its refurbishment are such that NB Power can afford to spend lots of time and resources to protect it.

NB Power also estimate that to retire PLGS would cost about $0.5 billion to put the plant in a state where its radioactivity would be contained, or perhaps returned to a green field state. This means that the net cost of refurbishment is the gross cost of $1 billion less the dollar value of postponing the mothballing for at least another 20 years.

Professor Gordon concluded by saying "I cannot imagine a greater disservice to the people of New Brunswick than the privatization of PLGS. Its sale would put an enormous financial burden on the province, since little or nothing could be realized from the sale. On the other hand, continued operation and refurbishment are very likely to have the excellent results just described. Furthermore, a buyer of PLGS would keep the money if things turned out well, and walk away if the opposite were true."

Comments (by Neil Craik)

- Nuclear Engineering International shows PLGS as having a cumulative lifetime capacity of 84.9% to Dec 1997. Hours of operation is a fair measure for PLGS which has usually run at full power, but would be invalid if the output of a plant has been limited.
- The new pressure tubes should last 30 years so the refurbished plant could last 30 years, but reduce to 25 years for conservative economic evaluation.
- Refurbishment cost of $1b seems high.

At the March 23 Hearing it was stated that the Point Lepreau nuclear plant, which NB Power wishes to maintain and operate as long as it is viable, will require $0.5b upgrade in 2008. This estimate is understood to include the direct costs of replacement of the reactor pressure tubes, calandria tubes and the steam generators plus the cost of loss of generation during the shutdown.

Prof. Gordon's point seems to be that NB Power could justify spending $1b on upgrading the plant which would allow a generous contingency to include some other refurbishments such as the following;

- Maintenance of the civil structures.
- Increasing the output of the turbine by replacing the last stage blades with modern "high twist" blades.
- The estimate of $0.5 billion to retire PLGS appears high.

The obligation of present society to "green field" all the things we have constructed such as roads, bridges, dams, steel works, and petrochemical plants, is debatable; certainly the there is no urgency to fully decommission PLGS to a green field site immediately after it is taken out of service.

The minimum requirement should be to simply ensure that the radioactive material could not leak out into the environment from existing structures.

The radioactive "spent fuel" bundles are presently stored on the site. This radioactive nuclear fuel is contained in the zirconium metal tubes of the original fuel bundles which are then placed and sealed in stainless steel baskets. Finally 10 of these baskets are placed in the reinforced concrete canisters. The whole assembly could also have a very long life.

Very long term containment of these radioactive materials may be possible with some maintenance of these existing structures. A fund of $100m should provide interest income sufficient for pay for the indefinite surveillance and maintenance of the structures. It could be argued that this should be the only liability that NBPower should carry on its books for nuclear decommissioning.

In 1990, the UK undertook a study on decommissioning using a strategy based on deferred safestore, in which the final decision on site clearance to greenfield or leaving the safestore in place is taken 135 years from the nuclear unit out of service.

The 13 gas cooled reactor stations in the UK each have two reactors. The total estimated cost for deferred safestore of all these 26 reactors in 1991 money was about £2,100 million. For PLGS, these figures can be divided by 26, which with rate of exchange of 2.5, and escalation to 1999$'s becomes $263m.

So the present NBPower estimate of $0.5b to retire PLGS, is quite generous.

In a presentation to the Select Committee in November 1998, Professor Secord, of the University of Saint Thomas in Fredericton, said that decommissioning might cost numerically as much as it took to build and suggested $1.5b (in today's dollars) as a guess but without any back up or clarification. This is another example of the kind of un-substantiated costs that have been presented as facts. In fairness to Professor Secord, he was rightly concerned about there being a stable reliable financial organisation in place to look after decommissioning.

Other Presentations

The writer submitted written comments on the Hay/Savoie report and verbally explained to the Select Committee, on November 17, 1998, that natural gas is not environmentally friendly. The Hay/Savoie report was comprehensive and thought provoking, but contained a number of statements shown in italics below, which the writer decided to challenge.

Following is an extract of the writer's presentation. (The statments in italics are from the Hay/Savoie report.)

> *"NB Power has built the right infrastructure, albeit at very high cost."*

What evidence is there that the NB Power infrastructure has been at a high cost and what comparison has been made to other electrical utilities?

For example; Point Lepreau NGS cost Can$1.4b (Can = US$1.12b in 1983) = US$1763/kWe. - In the US, the average cost of similar size single unit or first of two units in service in 1983 was US$ 2350/kWe.

Thus these, mostly privately owned, US nuclear power stations cost 28% more than Point Lepreau!

> *"The decision NB Power will make regarding investment to extend the life of Point Lepreau beyond 2008 will involve a comparison between the total costs of electricity production and the total cost at an alternative facility."*

For this comparison only the following estimated future costs of the generation of electricity from Point Lepreau after that 2008 date should be considered;

1) financing cost of the refurbishment over 25 years.
2) operating and maintenance costs based on past experience.
3) a reasonable estimate of annual ongoing refurbishment.
4) capacity factor of 80% (less than that achieved to date).
5) disposal costs of only the nuclear fuel discharged after the year 2008.

The following sunk costs should not be considered because these costs are unavoidable and would remain if Point Lepreau was taken out of service in 2008 for decommissioning;

a) The $450 million of the original fixed costs which will be left unamortized as of 2008.
b) The decommissioning costs
c) The storage costs for spent fuel produced before 2008.

However, for any proposed new replacement generating facility, all costs should be considered including amortization of the capital cost.

Thus a new privately owned generating plant should have to compete with a "new" nuclear generating plant of 635MW net capacity costing less than $1b with low and stable fuel costs and a lifetime of 25 years beyond 2008.

A new privately owned natural gas fired combined cycle gas turbine (CCGT) generating plant may have difficulty in competing with a refurbished Lepreau nuclear plant over 25 years, particularly because private owners will probably desire a full return on their investment in a much shorter period.

Realistic life-time rules of competition will have to be established if it is proposed that a new CCGT plant generating plant should prematurely decommission the Lepreau Nuclear plant.

> *"...any private sector entity which would contemplate operating/purchasing Point Lepreau would likely have a very significant operating experience...."*

Any private sector entity would likely be from the UK, Europe or the USA and therefore only have operating experience with light water or gas cooled reactors and not with the pressure tube, heavy water CANDU reactors which are very different in terms of operations (e.g on-load refuelling) and maintenance (management of heavy water and maintenance of the pressure tubes).

".... New Brunswick should not build another nuclear plant until the problems associated with decommissioning and disposal of spent fuel rods are solved."

It is absurd to imply that one should not build a second unit at Point Lepreau until the first unit has been taken out of service and decommissioned which takes years. Nuclear plants elsewhere have been successfully decommissioned.

There are no technical problems preventing the start of construction of a underground storage facility for permanent disposal of spent fuel rods. A political decision has to be made, at the appropriate time, to commence this task.

One reason for the delay in this political decision is that the spent fuel rods can remain indefinitely in the dry storage canisters contained within the concrete silos at the sites of the nuclear power stations in Canada such as at Point Lepreau. Political decisions tend to be put off as long as possible.

One advantage of on-site storage is that it postpones deciding the option of recovering the plutonium created and using the enormous amount of energy contained therein. This decision could be made by future generations when other fuels have run out or the detrimental effect of these other fuels on the environment have become more obvious.

"....natural gas offers environmental benefits over many of our current forms of generation."

Unburned natural gas is methane which is 30 times more potent as a greenhouse gas than the same weight of carbon dioxide (CO2).

Although methane concentrations are a minuscule fraction of those of CO2, of the possible 3-5°C global average temperature rise predicted for the middle of the next century, methane could account for 1 degree compared with 1_ degrees for CO2 and 1 degree for water vapour. The amount of methane in the atmosphere can be measured and has been increasing 1% annually (twice that of carbon dioxide) and so is of increasing concern.

Gas is leaked from gas wells, the production platform, the onshore gas processing plants, along the many miles of pipeline through fittings and compressor stations. The amount of this leakage is very difficult to estimate and can only be guessed. In contrast, what is discharged from a boiler stack can be measured. There is concern in not being able to measure the input of unburned natural gas to the environment.

Leakage from gas well, along pipelines to the power station burner is thought to be 1% in Canada, 1.5% in the USA, 2 - 4% in Russia.

So it is just assumed that in Canada, the amount of CO2 produced by gas fired generators (including equivalent pipeline methane leakages) is about half the CO2 from equivalent coal or oil fired generators, but which also produce NOX and SOX.

There is a misconception that natural gas is somehow better environmentally than electricity for home heating. This is only partially true if the natural gas is used to displace oil or coal fired electrical generation, and if the leakage of unburned natural gas is minimised.

A 5% leakage from the gas well to the power station burner negates the increase in thermal efficiency compared with coal.

Natural gas is not environmentally friendly. The term "natural" gives a deceiving nice warm friendly feeling.

In contrast, electricity produced by hydro or nuclear has no significant emissions.

Therefore it is important to minimize New Brunswick's contribution to GHG's and global warming and that advent of natural gas to the region should not undermine the long tern viability of Point Lepreau NGS as a means of generating electricity without emitting GHGs.

Natural gas fired gas turbine power stations may appear to be attractive in the short term because of their lower capital cost, but they contribute to GHGs both directly as methane leakage from the gas well and along the pipeline to the power station and as CO2 exhaust from the power station - even if only half the CO2 of an equivalent coal or oil fired station.

Therefore it is recommended that whatever restructuring and privatization is adopted, it should ensure that;

- Point Lepreau NGS is retubed and refurbished at an appropriate time - about 2008 - and continues in service until 2032.
- A second nuclear unit is constructed at Point Lepreau as soon as there is an sufficient increase in demand for electricity and at least put in service a few years before the existing first unit is decommissioned.

If necessary, any potential competition by gas fuelled power unit should be the charged with the cost of environmental externalities and require the fuel costs to be guaranteed over a long period.

The writer's presentation on the negative environmental impact of natural gas must have come as a surprise to the Select Committee as the only questions were on the possibility of selling Point Lepreau and the feasibility of life extension of the plant.

Professor Betts of the University of New Brunswick gave a presentation on November 17, 1998, in which he recommended that in order to reduce the NBPower $3.1b debt, most of the other NBP generating assets should be sold off soon because the price will be higher than later. Betts also estimated the market value of PLGS is only $190 million, compared with the nearby Coleson Cove oil fired station at $1b.

Final Comment

It is recognized that there is a big difference between the market value at which PLGS might be sold to a private owner who would assume all the risks, and its present real value to NBPower, but the Betts estimate is almost an order of magnitude lower that the writer's estimate of the value of PLGS to NBPower.

The following simple calculations of the present values of PLGS and the nearby Coleson Cove oil fired generating station have been made for comparative purposes and so have used the same following parameters;

Value of power at the switchyard; 6 cents/kwhr

Interest; 10%

Capacity factor; 80%

Point Lepreau NGS; 635 mw net output; in-service 1983

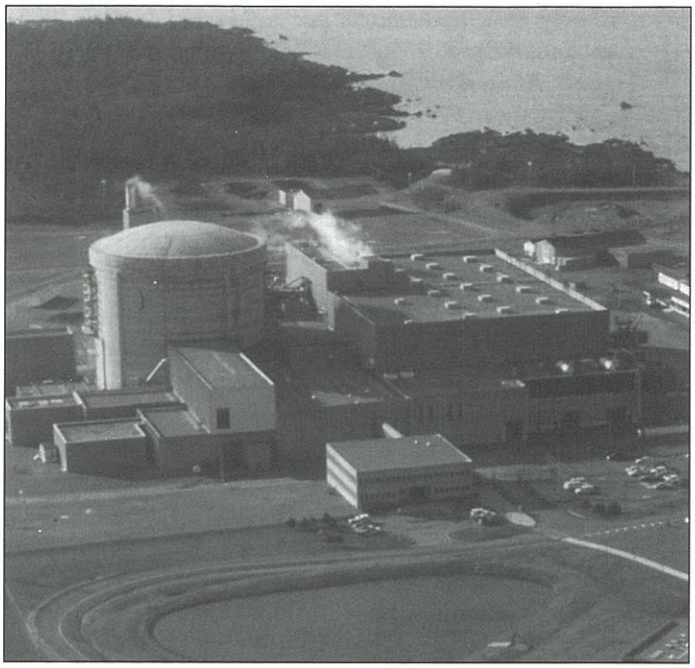
(a) PLGS Refurbished in 2008 at a cost of $1b.
Thereafter operated for 25 years.
Decommissioning allowance; present value $500m
Generating cost (fuel + OM&A); 4.3 cents/kwhr
Present value calculates as $1.4b.

(b) PLGS not retubed; Shutdown in 2008
Present value calculates at $0.98b

Coleson Cove, oil fired, 1006 mw net output, in service 1976
End of life; year 2015
Generating Cost (fuel + OM&A); 4.8 cents/kwhr
Present value calculates at $679m

The same 80% load factor has been used for Coleson Cove but this is very much higher than achieved historically because of environmental limits in burning the type of oil used.

As noted at the beginning, the Select Committee is expected to submit its report to the Legislature at the end of April 1999.



Point Lepreau nuclear generating station.

Safety Culture
- a view from the IAEA

by Ian Barraclough and Annick Carnino

Ed. Note: *The concept of "Safety Culture" is very pervasive in the realm of nuclear, especially, reactor, safety and the International Atomic Energy Agency has been in the forefront in promoting this approach. The following article is re-printed from the June 1998 issue of the IAEA Bulletin, the quarterly publication of the Agency. Both authors are in the IAEA's Department of Nuclear Safety, headed by Zig Domaratzki, formerly with the AECB. Annick Carnino is the Director of the Division of Nuclear Installation Safety and Ian Barraclough is a member of the Safety Coordination Section.*

Introduction

Principles of nuclear safety are now well known and being put into practice around the world, leading to a degree of international harmonization in safety standards. Recent experience, however – particularly in the States with long-established nuclear power programmes – indicates that the long-term management of safety calls for approaches that go beyond simple adherence to established design standards and operating procedures. Continued improvement in levels of safety requires the development of a comprehensive "safety culture" at all levels of an organization, with visible and consistent leadership from senior management.

Such a safety culture can make a substantial contribution to the principle of "defense-in-depth". It can promote the vigilance needed to recognize actual or potential safety problems and the communication and commitment needed to address them. External peer reviews and self-assessment can be important elements in strengthening safety culture. This article reviews the main elements required for establishing and sustaining a good safety culture at nuclear installations that involves staff at all levels.

Stages of Safety Culture

The International Nuclear Safety Advisory Group (INSAG) defines safety culture as "that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance." Safety culture is also an amalgamation of values, standards, morals, and norms of acceptable behaviour. These are aimed at maintaining a self-disciplined approach to the enhancement of safety beyond legislative and regulatory requirements. Therefore, safety culture has to be inherent in the thoughts and actions of all the individuals at every level in an organization. The leadership provided by top management is crucial.

When considering safety culture as practiced around the world, it is apparent that nearly all organizations involved in nuclear activities have in common a concern for safety and how to improve and maintain it. Yet there is substantial diversity among organizations in their understanding of "safety culture" and how to act to influence it in a positive way.

This variation is represented in different developmental stages. Three stages seem to emerge, each of which displays a different awareness and receptiveness to the effect of human behavioural and attitudinal matters on safety. The characteristics of each stage, identified below, provide a measure for organizations to use as a basis for self-diagnosis. The characteristics also may be used by an organization to give direction to the development of safety culture, by identifying the current and the aspired positions. It is possible for an organization at any time to exhibit any combination of the characteristics listed under each of one of these stages.

Stage I. The organization sees safety as an external requirement and not as an aspect of conduct that will help the organization to succeed. The external requirements are those of national governments, regional authorities, or regulatory bodies. There is little awareness of behavioural and attitudinal aspects of safety performance, and no willingness to consider each issues. Safety is seen very much as a technical issue. Mere compliance with rules and regulations is considered adequate.

Stage II. An organization at Stage II has a management which perceives safety performance as important even in the absence of regulatory pressure. Although there is growing awareness of behavioural issues, this aspect is largely missing from safety management methods which comprise technical and procedural solutions. Safety performance is dealt with, along with other

aspects of the business, in terms of targets or goals. The organization beings to look at the reasons why safety performance reaches a plateau and is willing to seek the advice of other organizations.

Stage III. An organization at Stage III has adopted the idea of continuous improvement and applied the concept to safety performance. There is a strong emphasis on communications, training, management style, and improving efficiency and effectiveness. Everyone in the organization can contribute. Some behaviours are seen within the organization which enable improvements to take place and, on the other hand, there are behaviours which act as a barrier to further improvement. Consequently, people also understand the impact of behavioural issues on safety. The level of awareness of behavioural and attitudinal issues is high, and measures are being taken to improve behaviour. Progress is made one step at a time and never stops. The organization asks how it might help other companies.

Management Roles & Actions

Four main requirements for managing safety effectively can be identified. These are strongly interrelated, but it is useful to discuss them separately:

- A visible and consistent commitment to safety from senior management, at both the corporate and plant level;
- A work environment conducive to a good safety culture;
- A commitment at all levels to develop and maintain a good safety culture; and
- A "humble" attitude, meaning that good safety performance is never taken for granted.

Senior management commitment to safety can be demonstrated by, for example, publicizing safety objectives (and monitoring progress towards meeting them), creating safety related posts with an appropriate level of authority, and establishing advisory committees or other mechanisms to involve staff and maintain interest in safety issues.

It should be stressed here that actions as well as words are essential in promoting a real safety culture; policies and committees need to be supported by positive management efforts to set a good leadership example and to give proper recognition for good safety performance. It is equally important that senior management strive to avoid actions that could be seen as undermining this commitment, such as overriding safety-related decisions made at lever levels, or placing great emphasis on cost-cutting without reference to maintaining safety.

Good safety management requires a work environment in which staff are well motivated and where their concerns and suggestions are listened to and acted upon. Open and effective two-way communication on safety issues throughout the management chain and across disciplines is an essential feature of such an environment; safety information needs to flow from the "top down" but also, equally important, from the "bottom up". Good safety culture depends upon workers identifying safety problems or opportunities for improvement and reporting these to supervisors. This is only likely to happen if the workers are encouraged to take an interest in safety issues and given the necessary training, and if they perceive some benefit in reporting such things (i.e. that there is a reasonable chance of their comments or suggestions being acted upon). On the other hand, it is most unlikely to happen if workers are simply blamed for problems that they report.

A good safety culture will be inherent in the thoughts and actions of individuals at all levels of an organization, creating a high quality defense-in-depth against technical, human, and organizational failures. Senior management should ensure that their organization has a safety management system that provides a structured and systematic means of achieving and maintaining high standards of safety performance.

Managers and supervisors need to motivate their staff to ensure that such a system is actually implemented on a day-to-day basis, and is not compromised by other pressures. Staff need to be aware of their responsibility for their own safety and that of their colleagues, not only in the way they perform tasks but also in identifying potential safety problems or improvements in their area of work.

A "humble" attitude implies consistent vigilance of safety matters, avoiding complacency when performance has been good, and maintaining a willingness to invite – and, when appropriate, implement – suggestions for improvement.

Operational feedback of experience – from the plant, from other parts of the organization, and from outside the organization – and, perhaps more importantly, the use of such feedback in the planning of work are crucial processes that need to be maintained throughout the life of a plant. Peer review and self-assessment – discussed in more detail below – can also play a major role in meeting this requirement.

The Role of Regulators

Regulatory inspection and enforcement are essential tools for monitoring nuclear safety at installations. Although the responsibility for managing safety rests with the operating organization, regulators can either help or hinder the process, depending on their attitude towards, inspection and enforcement. Regulatory approaches vary, but three general types can be observed. These could be seen, very broadly, as mirroring the three stages of safety culture discussed earlier.

"Compliance-based" regulation. This approach typically involves the regulator providing prescriptive standards and requirements – the same for every plant – for operators to follow. In this regime, inspection and enforcement are largely a matter of verifying compliance with these rules and penalizing non-compliance.

"Performance-based" regulation. In this approach, licensees are required to comply with safety objectives, but have some flexibility to decide how they achieve that. Safety performance indicators are used by the regulator to observe trends in safety, and inspection activities focus on these indicators.

A difficulty with this approach, however, is that the indicators used can be manipulated (i.e. efforts may be devoted to improv-

ing the indicators, rather than improving safety itself). Furthermore, it is difficult to find safety performance indicators that are predictive – i.e. that can be used to identify potential problems before they develop into real ones – and therefore this approach remains essentially reactive. As an example, one consequence of improving safety culture may be an increase in the number of safety related "events" or problems reported, as the result of better reporting by staff. It is important that regulators (as well as managers) are able to distinguish a positive trend of this type from a negative one in which more problems are occurring because of deteriorating safety performance. This requires a more sophisticated approach to inspection than simple "incident counting", and more positive safety indicators may be of value.

"Process-based" regulation. This approach takes specific account of the fact that the safe operation of nuclear facilities depends on the effectiveness of the organizational processes established to operate, maintain, modify, and improve a facility. Briefly put, the process approach focuses on the organizational systems that the facility has developed to assure the ongoing safe operation from the perspective of the facility's internal logic. It recognizes that the design of organizational processes must remain flexible in order to allow the facility to create processes that are internally consistent, adapted to their history, culture and business strategy, and that allocate resources in the most rational way. A process-based approach attempts to allow this flexibility while forcing the facility to think very carefully about the logic of their processes. It demonstrates to the regulator that they have taken a very rigorous approach to the design, implementation, and ongoing evaluation of their key processes and that they are alert to opportunities to improve their systems.

A combination of the above three approaches can be used, since they are not mutually exclusive.

Peer Review

Peer reviews are an important way of avoiding insular thinking on safety matters within an organization and broadening the range of "operational feedback". Reviews may be conducted by external organizations.

International peer reviews are offered by the IAEA, through such services known as OSART (Operational Safety Review Team), ASSET (Assessment of Safety Significant Events Team) and ASCOT (Assessment of Safety Culture in Organizations Team), and by the World Organization of Nuclear Operators (WANO). The Convention on Nuclear Safety, through its system of exchanging and reviewing detailed national reports, provides a further opportunity for international peer review of nuclear safety programmes and practices, at least at the national level.

Self-Assessment

The process of self-assessment is a way of proving some formal structure to the development of safety culture. It enables critical comparison of existing activities and results with a documented, predetermined set of performance expectations. These expectations need to take account of regulatory requirements as a minimum standard, but should aim to go beyond them to targets based on the best practice at top performing plants or organizations. The targets should therefore be reviewed regularly to ensure that they continue to promote improvement.

Self-assessment is intended to promote improved safety performance through the direct involvement of personnel in the critical examination and improvement of their own work, and to ensure that line management is effective in monitoring operational safety performance and takes timely corrective actions to improve performance. Staff involvement in the process can result in a better understanding of safety culture (in relation both to their own jobs and the organization as a whole), a broadening of knowledge of the objectives to be achieved, and the means for achieving them. It can also help to promote good communications within the organization.

The process of self-assessment can be complemented by audits, carried out by competent people who are independent of the area or activities being audited (from other parts of the organization or from another organization). Again, there may be different "styles" of audit, ranging from simple compliance-checking to a much more wide ranging and interactive review of the quality of the processes involved. Pre-audit meetings can help to ensure that the audit will be conducted constructively.

In view of the benefits it holds, the process of self assessment will soon become the key to continued progress in safety management.

meetings

CNA/CNS Winter Seminar

Jean MCloskey

A major focus of the annual Nuclear Industry Winter Seminars held by the Canadian Nuclear Association and the Canadian Nuclear Society has always been to inform leaders at the federal government level of the importance and value of the nuclear program in Canada. In that regard the 1999 Seminar, held in Ottawa, the evening of February 8 and all day February 9 was particularly successful.

Some 90 government representatives (Members of Parliament and senior officials) joined a slightly larger number of industry people at the reception and dinner, February 8, at which Jean McCloskey, deputy minister, Natural Resource Canada, was the guest speaker. Ms. McCloskey touched on a number of events over the previous year, including: the COP 4 meeting on global warming with the implications for nuclear power, and the Seaborn report on nuclear fuel disposal concept. She echoed her Minister's (Ralph Goodale) comment at the 1998 Seminar about the problem of public perception. "The industry must do a better job in getting its message out", she warned.

The next day saw a parade of senior people associated with the Canadian nuclear program present concise, and sometimes incisive, views on a spectrum of topics.

David Whelan, director general, Energy Resources Branch, NR Can., began the day with a report on the federal government's response to the report of the Seaborn panel. (See CNS Bulletin, Vol. 19, No. 4). He noted the public consultation process then underway on the proposed government "oversight" mechanism.

Carl Andognini, chief nuclear officer, Ontario Hydro Nuclear, gave an update on OHN's nuclear recovery program. He noted a number of accomplishments in the areas of: managerial leadership; culture and standards; communications; people and performance; process and procedures; hardware and design; organization and resources; labour relations; and, stakeholder support. For 1999 he emphasized that safety continued to be the number one focus. The NAOP "12/16/20" strategy will be pursued, outage and environmental performance will be improved, and, Y2K compliance will be ensured. He commented that a Pickering "A" Integrated Restart Plan would be released in April 1999.

Jim Harvie

Rod White, vice-president, New Brunswick Power, provided a status report on the Point Lepreau Generating Station. A major question being investigated is the full scale introduction of CANFLEX fuel. He noted the legislative hearings being held on the future of NB Power (see article in this issue of the CNS Bulletin).

For his update on the uranium mining sector, Arnaud de Bourayne, president of Cogema Resources Canada, titled his talk, "A Baffling World for Uranium Producers". He explained that there are now three basic sources for uranium supply: production from the countries s of the former USSR; inventories (including that coming from dismantled nuclear weapons); and, western production. Although production in the former USSR countries is declining and western production is only 50% of current demand, spot prices are very low, largely because utilities in the USA entered into long-term contracts over the past few years. A particular problem in developing new mines, he argued, is the ever increasing complexity of regulatory requirements and the resulting long time delays. As an example, he cited Cigar Lake where more than half of the 20 years spent in developing the project has been spent in regulatory processes.

Jim Harvie, director general, Reactor Regulation, Atomic Energy Control Board, gave one of his typical acerbic comment on the Canadian nuclear power program from a regulator's viewpoint. Referring to the situation at Ontario Hydro he commented that it was "humbling" that no Canadian was available to restore the utility's nuclear program. He described OHN"s Nuclear Asset Recovery Program as "militaristic", and noted, that from the AECB's perspective, the progress was slow and inconsistent. Despite this, he asked, could Ontario Hydro's nuclear program be turned around without bringing in US experts, and answered, no, because a major cultural change was needed.

Allen Kilpatrick, president of Atomic Energy of Canada Limited, modified his CANDU update with a paper he titled, "A

Look Back and a Look Forward .. or.. The More Things Change ...". After reviewing the "heady" earlier days he noted the reduction of government appropriation to AECL (for basic R & D) in the early 1990s and the dramatic change form domestic projects to total dependance on off-shore markets. Looking ahead his "Vision 2002" included:

- the Canadian Neutron Facility under construction
- refurbishment of Chalk river Laboratories underway
- Pickering "A" returned to service
- two CANDU 6 units under construction in Turkey
- a MAPLE under construction in Australia
- a commitment to CANDU 9 in Korea.

Two presentations dealt with the global warming issue and the role of nuclear power.

Ian MacGregor, deputy head, Climate Change Secretariat, reviewed the process underway to develop a Canadian strategy for implementing the Kyoto commitments (for reduction of "greenhouse gas" emissions). A number os sector "foundation" papers are being prepared, which will be put on their Web site this spring. On the international front he noted on-going negotiations on : international emission trading; joint implementation; and, clean development mechanisms.

Murray Stewart, president, Canadian Nuclear Association, provided a concise and clear argument for nuclear power as an essential element in meeting the world's Kyoto commitments. (His paper is available ion the CNA web site.)

Grant Malkoske, vice-president, MDS Nordion, gave a positive overview of the radioisotope business, noting the new venture of MDS Nordion to produce a radiopharmaceutical that will specifically target non-Hodgkin's lymphoma. He expressed frustration at the continued refusal of Health Canada to approve more products for food irradiation, despite considerable movement in the USA and international approvals by the World Health Organization and the Food and Agriculture Organization.

Former AECL staff, Bob Dixon and Len Simpson, chat with AECL chairman Bob Nixon at the CNA/CNS Winter Seminar, Ottawa, Feb. 8, 1999

Paul Lafreniere, general manager, Operations, AECL Chalk River Laboratories, closed the seminar with an update on the Chalk River Laboratories, emphasizing the need for replacement of NRU and refurbishment of many of the buildings.

No proceedings are prepared of the Winter Seminars but several of the speakers had prepared texts which may be available.

Twentieth Annual Conference of the Canadian Nuclear Society

Hilton Bonaventure Hotel, Montréal, QC, Canada May 30 - June 2, 1999

The 20th Annual Conference of the Canadian Nuclear Society will be held in conjunction with the 38th Annual Conference of the Canadian Nuclear Association in Montréal, Québec, Canada, May 30 - June 2, 1999.

(See detailed programs in this issue of the CNS Bulletin.)

To register or for information contact:

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Fax 416-979-8356
E-mail: carons@cna.ca

24th Annual CNA/CNS Student Conference
- small but very good

There may have been fewer participants than in the past years but the papers at the 1999 CNA/CNS Student Conference were of a high quality.

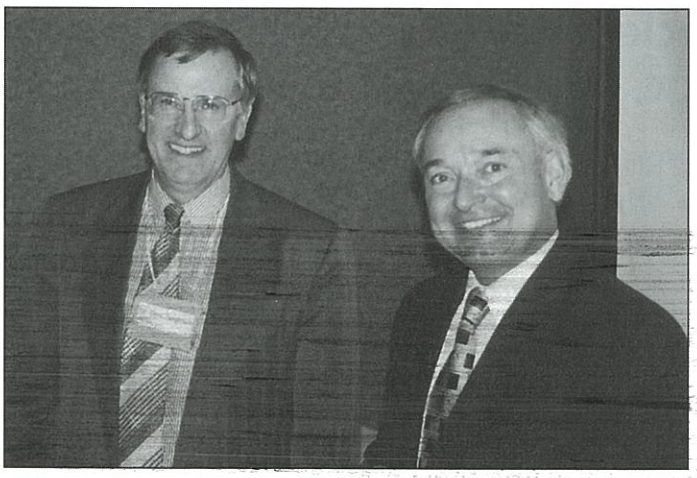
This event, the 24th such conference, was held at Trent University in Peterborough, Ontario, with Dr. Jim Jury, a professor of physics, as the convenor. The series of conferences for students of nuclear-related studies was begun in 1976 under the auspices of the Canadian Nuclear Association. With the formation of the Canadian Nuclear Society in 1979 that society took over the primary responsibility for the student conferences, with the CNA continuing to provide some financial assistance.

With the smaller number this year the format was modified to a one-day event, on Saturday, March 27, 1999. This was augmented by a dinner on the Friday evening at which Dr. David Torgerson, vice-president at Atomic Energy of Canada Limited, was the guest speaker. Torgerson gave an up-beat overview of the current Canadian nuclear program and left a message with the students that they had excellent prospects in the future.

At the luncheon during the Saturday session Jury gave a short presentation on a process he and others have developed for detecting plastic land mines, using neutron activation techniques. He noted that they had received patents for the process only two weeks previously. *(Hopefully, a report on this new approach will be in the next issue of the* CNS Bulletin.)

Later on Saturday afternoon the group was treated to a tour of the General Electric Canada fuel and fuelling machine manufacturing facilities, hosted by Paul Hynes and Bill Knowles.

Indicative of the sophistication of the students, several of the presentations were computerized, running off laptops through electronic projectors. Despite the relatively small numbers, the high quality of the papers proved a challenge for the judges: Bill Garland (McMaster University); Brent Lewis (Royal Military College); and Ben Rouben (AECL). Their final decision was:



AECL V.P. David Torgerson (left), guest speaker, poses with Jim Jury, convenor at the 1999 CNA/CNS Student Conference in Peterborough, March 26.

Shown are winners of the 24th CNA/CNS Student Conference held at Trent University, March 28, 1999. Left to right: David Novog, Marie-France Bourgeois, Andree Gingras-Genois, Christopher Cole.

Undergraduate (tie)

Marie-France Bourgeois, Universitè Laval

Suivi in vivo en imagerie par résonance magnétique, d'acides polylactiques implantés dans le muscle dorsal du lapin.

A. Gingras-Genois, Universitè Laval

Effet de la température sur la lixiviation des matériaux cimentaires.

Graduate (tie)

Christopher Cole, Royal Military College

Numerical prediction of the oxygen potential in the GAP of defective CANDU fuel rods during serious accident conditions.

David Novog, McMaster University

Void distribution measurement of swirl-flow boiling Freon by real-time neutron radiology and high-speed X-ray computed tomography.

All of the papers were printed in nicely bound set of "Transactions" which should be available through the CNS office.

The next student conference will be held at McMaster University in March 2000. Anyone wishing early information can contact Prof. Bill Garland, e-mail: < garlandw@mcmaster.ca >.

CNA 39th Annual Conference, Montréal, Québec
May 30 - June 2, 1999
Preliminary Program

Sunday, May 30

10:00 a.m. Golf – Golf Dorval (near dorval airport) (optional extra)
13:30 - 20:00 Registration
16:00 - 16:30 CNA Annual General Meeting
16:30 - 17:00 CNA Board meeting
18:00 - 20:00 CNA/CNS Welcome Reception

Monday, May 31st

7:30 - 17:00 Registration - Main Foyer

8:30 - 11:30 Session 1
JOINT CNA/CNS PLENARY SESSION

Welcome from the CNA: Murray J. Stewart, President & CEO Canadian Nuclear Association
Welcome from the CNS: V.S. (Krish) Krishnan, Incoming President Canadian Nuclear Society

Introduction from Conference Co-Chair:
René Godin, President & CEO
Canatom NPM Inc.

Keynote Speaker: Hon. Ralph Goodale,
Minister of Natural Resources Canada (invited)

Session Chair: Tom Gorman, Chairman
Canadian Nuclear Association

1. André Caillé, President & CEO - Hydro-Québec
2. Bernard Michel, Chairman, President & CEO - Cameco Corporation
3. Allen Kilpatrick, President & CEO - Atomic Energy of Canada Limited
4. John Morrison, President & CEO - MDS
5. Ron Osborne President & CEO - Ontario Hydro
6. Mike ClelandAssistant Deputy Minister, Energy Sector - Natural Resources Canada

12:00 - 14:00 CNA Awards Luncheon

14:00 - 17:00 CNA Session 2
THE DOMESTIC SCENE

Session Chair: Yves Filion, Deputy Chief Executive Officer - Hydro-Québec

1. Ghislain Ouellet, Executive Vice-President Generation - Hydro-Québec
2. Cogema - to be announced
3. Rod White, Vice-President - New Brunswick Power
4. John Fox, Executive Vice-President and Managing Director - Ontario Power Generation Co. (GENCO),
5. Ken Nash, Vice-President Waste Management - GENCO
6. Low Level Nuclear Waste - to be announced

14:00 - 16:30 CNS Parallel Technical Session 1
(see CNS program)

17:00 - 18:30 CNS Annual General Meeting

Tuesday, June 1st

7:30 - 16:00 Registration

8:30 - 11:30 Session 3
THE INTERNATIONAL SCENE

Session Chair: Allen Kilpatrick, President & CEO - Atomic Energy of Canada Limited

1. Climate Change - Murray J. Stewart, President & CEO - Canadian Nuclear Association
2. Europe - to be announced
3. USA - Angelina S. Howard, Senior Vice-President, Industry Communications - Nuclear Energy Institute
4. China - to be announced
5. Korea - to be announced
6. HEU and uranium supply situation - to be announced

8:30 - 11:30 CNS Parallel Technical Session 2
(see CNS program)

11:45 - 13:45 CNS Awards Luncheon

14:00 - 16:30 CNA Session 4
CANADA'S INTERNATIONAL NUCLEAR BUSINESS

Session Chair: René Godin, President & CEO - Canatom NPM Inc.

1. Ken Petrunik, Vice-President and Project Director, Qinshan - AECL
2. Bill Hancox, Vice-President Marketing and Sales - AECL
3. Grant Malkoske, Vice-President Engineering and Technology - MDS Nordion Inc.
4. Ron Field, Vice-President - Canatom NPM Inc.
5. Uranium exports/markets - to be announced
6. Paul Koenderman, President - Babcock and Wilcox Canada

14:00 - 16:30 CNS Parallel Technical Session 3
(see CNS program)

FUN NIGHT **Casino de Montreal**
17:30 - 18:00 Transportation
18:00 - 24:00 Dinner and Casino
SINATRA... REMEMBERED : THE SHOW

Wednesday, June 2nd

8:30 - 14:00 Registration

9:00 - 11:30 Session 5
JOINT CNA/CNS PLENARY SESSION
COMMUNICATIONS -
THE STORY OF WASTE

Session Chair: Rhea Cohen, Director, Communications - AECL
1. North American panelist - to be announced
2. European panelists - to be announced
3. Asian panelist - to be announced

12:00 - 14:00 CNA/CNS Closing Luncheon
Guest Speaker: ANN MEDINA

14:00 - 17:00 Technical Tours
Technical tours are currently planned for:
CAE Electronics Ltd., Côte-de-Liesse plant,
Hydro-Québec Control Centre
Velan Inc. Ville St-Laurent plant.

20th Annual Conference of the Canadian Nuclear Society
May 30 - June 2, 1999
Preliminary Program

Monday, May 31

SESSION A1: RADIOCHEMISTRY / RADIATION

14: 00 - 14: 25 *Determination of 17 Elements in 20 Canadian Mineral Waters by Evaporation and Systematic Instrumental Neutron Activation Analysis*
Pham Van DUONG, Ecole Polytechnique
Lubomir ZIKOVSKY, Ecole Polytechnique

14: 25 - 14: 50 *Thin Layer Activation: A Radiotracer Technique for Measuring Wear in Real Time*
Kenneth OXORN, ANIQ
Yves B. TRUDEAU, ANIQ
Wen Chao CHEN, ANIQ

14: 50- 15: 15 *ChemAND - A System Health Monitor for Plant Chemistry*
C. W. TURNER, AECL
G. R. BALAKRISHNAN, AECL
P. V. MITCHEL, AECL
et al.

15: 45 - 16: 10 *Inspection Surveys of X- Ray Inspection Systems: Results of Five Years and Implications on Future Management of Radiation Risks*
H. P. MAHARAJ, Health Canada, RPB

BREAK

16: 10 - 16: 35 *Commercial Aircrew Radiation Dosimetry using a Tissue Equivalent Proportional Counter*
A. R.GREEN, Royal Military College
B. J. LEWIS, Royal Military College
L. G. I. BENNETT, Royal Military College

14: 00 - 14: 25 *The Solution of Sparse Matrices in CATHENA*
Thomas G. BEUTHE, AECL
J. B.HEDLEY, AECL

SESSION A2: THERMALHYDRAULICS 1

14: 25- 14: 50 *Application of the CATHENA Thermalhydraulics Code to MAPLE Research Reactor Safety Analysis*
Nick K. POPOV, AECL
Raphaël KOUYOUMDJIAN, AECL
Harvey SILLS, AECL
et al.

14: 50 - 15: 15 *Endshield Response to Impact Velocity Due to Reverse Flow Resulting from Large LOCA*
N. N. WAHBA, Ontario Hydro
M. H. BAYOUMI, Ontario Hydro
J. K. CHAN, Ontario Hydro

15: 45 - 16: 10 *CANDU 9 Large LOCA Uncertainty Analysis*
Amad ABDUL- RAZZAK, AECL
Maw- Rong LIN, AECL

BREAK

16: 10 - 16: 35 *ASSERT- PV Simulations of Two- Phase Flow in Subchannels*
J. W. PARK, KAERI
K. M. CHAE, KAERI
H. CHOI, KAERI

16: 35 - 17: 00 *Flow Stability of Liquid Metal Flow Under Transverse Magnetic Field*
Hee Reyoung KIM, KAERI
Ho-Yun NAM, KAERI
Yong-Kyun KIM, KAERI

14: 00 - 14: 25 *Evaluation of Supercell Methodologies using ZED- 2 Measurements*

Benoît ARSENAULT, AECL
H. C.CHO, WAECL

SESSION A3: REACTOR PHYSICS 1

14: 25 - 14: 50 *Measurements of Thermal Neutron Flux Distributions in the NRU Loops*

Timothy LEUNG, AECL

14: 50- 15: 15 *MCNP Analysis of a D2O- Filled Fuel Channel Penetration Through the End Shield*

L. KIRILOVSKY, K. T.
K. T. TSANG, K. T.

15: 45 - 16: 10 *Development of an Isotopic Depletion Method for Reactor Core Calculation*

M.BOUCHER, Ecole Polytechnique
Guy MARLEAU, Ecole Polytechnique
Daniel ROZON, Ecole Polytechnique

BREAK

16: 10 - 16: 35 *Development of Limiting Decay Heat Values*

V. A. KHOTYLEV, Atlantic Nuclear
J. W. THOMPSON, S i Ltd Atlantic Nucl. Services Ltd
R. A. GIBB, NewBrunswick Power

14: 00 - 14: 25 *Application of Experience to the Design of the Steam Generators for the CANDU 9*

James C. SMITH, Babcock & Wilcox Canada

SESSION A4: OPERATIONS AND MAINTENANCE 1

14: 25- 14: 50 *On the Prediction of Fretting Wear of Nuclear Steam Generator Tubing*

I. SRINIVASAN, Babcock & Wilcox Canada

14: 50 - 15: 15 *Steam Separator Replacement for Bruce B Unit #8*

W. SCHNEIDER, Babcock & Wilcox Canada
C. HOLMES, Babcock & Wilcox Canada
J. TANG, Babcock & Wilcox Canada

BREAK

15: 45 - 16: 10 *Primary Divider Plate Replacement at Pickering Nuclear Gererating Station B*

G. WANGERSKY, Babcock & Wilcox Canada
J. ALBERT, Babcock & Wilcox Canada
J. CAO, Babcock & Wilcox Canada

16: 10 - 16: 35 *Pressurizer Manway Closure Reengineering*

R. HORVATH, Babcock & Wilcox Canada
J. TANG, Babcock & Wilcox Canada

16: 35 - 17: 00 *A Study on the Effectiveness of the High Capacity Blowdown on the Sludge Removal in the Steam Generator*

Se Jin BAIK, KOPEC

TUESDAY, June 1

SESSION B1: INSTRUMENTATION AND CONTROL

09: 00 - 09: 25 *Measurement of the Dynamic Response of Differential Pressure Transmitters Using a Response Time Tester*

H. W. HINDS, AECL

09: 25 - 09: 50 *Determining Prompt Fractions of In- Core Flux Detectors During Full- Power Operation in CANDU*

B. SUR, AECL
J. JOHNSTON, AECL
P. TONNER, AECL

09: 50 - 10: 15 *The Measurement and Analysis of the Dynamic Response of Alarm Units*

H. W. HINDS, AECL

10: 45 - 11: 10 *Dynamic Response of the SDS Flow-Measurement System in CANDU*

V. T. KOSLOWSKY, AECL
H. W. HINDS, AECL
P. D. TONNER, AECL
et al.

BREAK

11: 10 - 11: 35 *Computing Channel RTD Systematic Errors Using Small Reactor Derates*

V. COSTIUC, Atlantic Nuclear Serv. Ltd
J. HANDBURY, Atlantic Nuclear Serv. Ltd
T. WHYNOT, New Brunswick Power

SESSION B2: THERMALHYDRAULICS 2

09: 00 - 09: 25 *A Comparison of Assert Predictions against Equilibrium Void Distribution Experiments*

Peter TYE, Ecole Polytechnique
Alberto TEYSSEDOU, Ecole Polytechnique
Pascal HERNU, Ecole Polytechnique

09: 25 - 09: 50 *Prediction of the Flooding Point in a Vertical to Horizontal Tube With and Without Obstructions*

Peter TYE, Ecole Polytechnique
Alberto TEYSSEDOU, Ecole Polytechnique
Altan TAPUCU, Ecole Polytechnique

09: 50 - 10: 15 *Coherent Structures in the Gaps of Rod Bundles*

M. S. GUELLOUZ, University of Ottawa
S. TAVOULARIS, University of Ottawa

10: 45- 11: 10 *Thermalhydraulic Characteristics of CANDU 9 Moderator*

Ji ZHANG, AECL
Maw-Rong LIN, AECL

BREAK

11: 10 - 11: 35 *Assessment of Fuel Cooling Under Shutdown Conditions in Gentilly 2*

Parviz GULSHANI, AECL
Hong HUYNH, Hydro-Québec

11: 35 - 12: 00 *Calculation of ECCS Flow Rates at Wolsong Plants*

Dong Ha KIM, KAERI

09: 00 - 09: 25 *Validation of WIMS- AECL / 3DD Code Package Using the IAEA 10 MW Benchmark Problem for the McMaster Nuclear Reactor Fuel Conversion Analysis*

Hassan ALBASHA, McMaster University

SESSION B3: REACTOR PHYSICS 2

09: 25 - 09: 50 *Self-Collision Rebalancing Technique for the MCI Characteristics Solver*

G. J. WU, Ecole Polytechnique
Robert ROY, Ecole Polytechnique

09: 50 - 10: 15 *Generation of Microscopic Pseudo-Fission Products Properties*

H. BENJAAFAR, Ecole Polytechnique
Guy MARLEAU, Ecole Polytechnique

10: 45 - 11: 10 *The Effect of PWR Fuel Management Strategy on DUPIC Fuel Cycle*

Wei SHEN, Ecole Polytechnique
Daniel ROZON, Ecole Polytechnique

BREAK

11: 10 - 11: 35 *Experimental and Computational Determination of Radiation Dose Rates in the Slowpoke-2 Research Reactor at the Royal Military College of Canada*

Greg B. LAMARRE, Royal Military College
Hugues W. BONIN, Royal Military College

11: 35 - 12: 00 *Development of NDA Measurement Method to Determine Fissile Material Contents for DUPIC Fuel*

Hee Young KANG, KAERI
Hong Ryul CHA, KAERI
Gil Mo KU, KAERI
et al.

SESSION B4: OPERATIONS AND MAINTENANCE 2

09: 00 - 09: 25 *Development of Special Tools for Reactor Internal Cleaning in HANARO*

Yeong-Garp CHO, KAERI
Jong-SupWU, KAERI
Byung-Ho KWAG, KAERI
et al.

09: 25 - 09: 50 *Significance of Beta and Gamma Dose on Environmental Qualification of Components*

K. M. AYDOGDU, AECL
T. K. TSANG, AECL

09: 50 - 10: 15 *Characterization of the Electromagnetic Environment for Instrumentation and Control Equipment in CANDU*

W. KALECHSTEIN, AECL

10: 45 - 11: 10 *The Unavailability and Delay Time of an Action Due to the Drift of the Instruments*

Huang TANG, New Brunswick Power

BREAK

11: 10 - 11: 35 *CANFLEX Demonstration Irradiation at Point Lepreau: Background and Observations*

R. A. GIBB, New Brunswick Power
R. W. SANCTON, New Brunswick Power
P. J. REID, ALARA Research Inc.
et al.

11: 35 - 12: 00 *Point Lepreau Generating Station Strategic Planning Process Integrating Strategic Objectives Into Operational Planning*

Syd TURNER, New Brunswick Power

14: 00 - 14: 25 *Improvements to the Control Room Operator Workspace at Point Lepreau*

Tom HITCHCOCK, New Brunswick Power
Eric DAVEY, Crew Systems Solutions
Bryan PATTERSON, Human Factors Practical
et al.

SESSION C1: CONTROL ROOM OPERATIONS

14: 25 - 14: 50 *Control Room Monitoring of Process Conditions and Identificationof Improvements to Darlington Monitoring Displays*

Eric DAVEY, Crew Systems Solutions
Mark TONELLO, Ontario Hydro
Diego RIVERA, AECL

14: 50 - 15: 15 *Implementation of New Operations Standards at Darlington Nuclear Generating Station*

Ron CHATTERTON, Ontario Hydro

BREAK

15: 45 - 16: 10 *Evaluating Nuclear Power Plant Crew Performance During Emergency Drills*

Doron RABIN, AECB
Lucinda STAPLES, AECB

16: 10 - 16: 35 *Psychological Error Mechanisms*

B. K. PATTERSON, Human Factors Practical

16: 35 - 17: 00 *Improving Performance Through a Professional Development*

Keith SCOTT, Atlantic Nuclear Services Ltd

14: 00 - 14: 25 *MAPLE Research Reactor Safety Margins Uncertainty Assessment Methodology*

H. E. SILLS, AECL
R. B. DUFFEY, AECL
T. H. ANDRES, AECL

SESSION C 2: SAFETY

14: 25 - 14: 50 *Fission- Product Transport and Retention in the PHTS Under Accident Conditions*

Lawrence W. DICKSON, AECL
Raymond S. DICKSON, AECL

14: 50 - 15: 15 *Computer Simulation of Aerosol Dynamics Using CONTAIN with a Modified Kernel*

Y. TRUDEAU, ANIQ
W. C. CHEN, ANIQ
C. K. SCOTT, ANIQ
et al.

15: 45 - 16: 10 *Implementation of Common Industry Safety Analysis Codes*

J. LUXAT, Ontario Hydro
V. SNELL, AECL
M. A. PETRILLI, Hydro-Québec
et al.

BREAK

16: 10 - 16: 35 *Graphical Environment Pathway Analysis Software TEDII- 60 Incorporating ICRP- 60 Recommendations*

Sang-Ho KANG, KOPEC

16: 35 -17: 00 *Quality Assurance Implementation and Effectiveness for CANDU 9 Program*

J. HUTERER, AECL

14: 00 - 14: 25 *Comparison of MCNP4B and WIMS- AECL Calculations of Coolant Void Reactivity Effects for Uniform Lattices of CANDU Fuel*

Kenneth S. KOZIER, AECL

SESSION C 3: REACTOR PHYSICS 3

14: 25 - 14: 50 *Verification of Two- Group CERBERUS for a Loss-of-Coolant Analysis in a Simplified Reactor Analysis*

James DONNELLY, AECL

14: 50 - 15: 15 *The Improved Quasistatic Method vs the Direct Method: A Case Study for CANDU Reactor Transients*

Siamak KAVEH, Ecole Polytechnique
Jean KOCLAS, Ecole Polytechnique
Robert ROY, Ecole Polytechnique

BREAK

15: 45 - 16: 10 *Simulation of CANDU Reactor Transients Using Three Level Space Time Kinetics*

Siamak KAVEH, Ecole Polytechnique
Jean KOCLAS, Ecole Polytechnique
Robert ROY, Ecole Polytechnique

16: 10 - 16: 35 3D *Computer Visualization and Animation of CANDU Reactor Core*

T. QIAN, AECL
M. ECHLIN, AECL
P. TONNER, AECL
et al.

14: 00 - 14: 25 *Instrument Development for Safeguards Implementation on Spent CANDU Fuels in Korea*

Y.- G. LEE, KAERI

SESSION C 4: Q. A./ REGULATORY / WASTE MANAGEMENT

14: 25 - 14: 50 *Waste Management Study for Disposition of Uranium Metal Fuelfrom North Korea*

Michael ATTAS, AECL

14: 50 - 15: 15 *Regulatory Considerations of Lay- Up of Power Reactors*

Patrick G. HAWLEY, AECB

BREAK

15: 45 - 16: 10 *Three Mile Island Litigation 20 Years Later: Any Lessons for Canadian Utilities*

Martin REESINK, Ottawa University

16: 10 - 16: 35 *The Year 2000 (Y2K) Program for Scientific-Analysis Computer Programs at AECL*

Jad POPOVIC, AECL
Cheryl GAVER, AECL
Dawn CHAPMAN, AECL

16: 35 - 17: 00 *Future of Nuclear Power in the World and in Canada*

Jovan V. JOVANOVITCH, University of Manitoba

SESSION C 5 : GENERAL / APPLICATIONS

14: 00 - 14: 25 *Nuclear Energy in Industry: Application to Oil Production*

John DONNELLY, Marengo Energy Research
Duane PENDERGAST, AECL

14: 25 - 14: 50 *Nuclear Power and Carbon Dioxide Free Automobiles*

Duane R. PENDERGAST, AECL

GENERAL news

The Breakup of Ontario Hydro

As of April 1, 1999, Ontario Hydro no longer exists.

The "Energy Competition Act" (Bill 35), which was passed last fall dissolved Ontario Hydro as of midnight March 31, 1999, and created four successor entities:

- Ontario Power Generation Inc.
- Ontario Electric Services Company Inc.
- Ontario Electricity Financial Corporation , and
- the Independent Electricity Market Operator

Ontario Power Generation Inc. becomes the owner (for now) of all of the former Ontario Hydro's generating facilities. Ontario Electric Services Company Inc. will own and operate all of the transmission systems (and some local distribution systems). Ontario Electricity Financial Corp. Will hold and service all of Ontario Hydro's debt and will receive payments from the two operating companies. The Independent electricity Market Operator is a separate, not-for-profit organization which will enable consumers to contract with various generators for the supply of electricity.

Background

The Hydro-Electric Power Commission of Ontario (HEPCO) was formed in 1906, largely as a result of the lobbying and leadership of Adam Beck, then mayor of London, Ontario and an Minister of the Ontario legislature. There had been proposals from a private US firm to develop the Canadian side of Niagara Falls and sell electricity to the privately owned Toronto Electric Light Co. and the Toronto Street Railway. Beck pushed for public ownership and gained strong public support. In May 1906 he introduced a Bill for "An Act to Provide for the Transmission of electrical Power to Municipalities" which was passed the same month and HEPCO was created.

Beck was appointed chairman of HEPCO, a position he held until his death in 1925. Under his leadership the Commission expanded into generation as well as transmission, but Beck promoted the concept that HEPCO was a trustee of a municipal cooperative.

Initially all of the power was generated by hydro sources and the term "hydro" became synonymous with "electricity" in Ontario, to the confusion of visitors from outside the province. In the 1950s the readily usable hydro sites had been used and HEPCO turned first to fossil-fuelled plants, then joined with Atomic Energy of Canada Limited in the study of nuclear power. The small (20 Mwe) NPD demonstration plant, which was a joint venture of the two organizations (with a contribution from Canadian General Electric that did the engineering), started up in 1962.

In 1973 the province passed the "Power Commission Amendment Act" which converted the commission into a corporation and changed the name to "Ontario Hydro". Over the two and a half decades from the late 1960s to the early 1990s Ontario Hydro built 20 large nuclear power units, all of the CANDU design, at sites at Pickering near Toronto, Bruce on the shores of Lake Huron and Darlington, 50 km. east of Pickering.

Canadian Nuclear Society / Société Nucléaire Canadienne
CNS/SNC Inc.

NOTICE OF 2nd ANNUAL GENERAL MEETING
AVIS DE RÉUNION DE LA 2ième ASSEMBLÉE GÉNÉRALE ANNNUELLE

DATE:	MONDAY, 1999 MAY 31 / LE LUNDI 31 MAI 1999
TIME/ HEURE:	17:00 H
PLACE / ENDROIT:	HÔTEL MONTRÉAL BONAVENTURE HILTON MONTRÉAL, QUÉBEC SALLE MONT-ROYAL ROOM

Pickering licence renewed for two years

Following its meeting of March 25, 1999, the Atomic Energy Control Board granted a renewal of the Operating Licence for the Pickering station for the normal period of two years.

AECB staff presented an extensive report on their review of operations at Pickering and the progress on a number of problem areas identified in the past. Although the staff identified many items as "conditionally acceptable" they concluded that sufficient improvement had taken place that a two-year licence was appropriate. Staff recommended that they come back to the Board in a year with a comprehensive review but the Board decided to order Ontario Power Generation Inc. to do so.

Four interventions were made at the meeting, including ones from the towns of Ajax and Pickering, both of which gave equivocal support for the re-licensing. The other two were from Durham Nuclear Awareness which urged the shutdown of Pickering B and the Citizens for Renewable Energy, which recommended a nine-month licence to "coincide with the end of the millennium". Another 35 written submissions, mostly critical or calling for the shutdown of Pickering, were tabled.

At the same meeting the Board approved the transfer of the reactor operating licences held by Ontario Hydro to Ontario Power Generation Inc.

AECB approves COGEMA tailings facility

After many months on again, off again stance regarding the Tailings Management Facility at McLean Lake, using the mined-out JEB pit, at its March 25, 1999 meeting, the Atomic Energy Control Board granted approval to Cogema Resources Inc. to proceed with the construction of the proposed facility.

Approval to proceed with preliminary construction had been granted in August 1998. But in October The AECB issued a stop work order when AECB staff reported that off-specification fine rock had been used. That order was lifted in November but further discrepancies were identified in December and the order re-imposed.

The new mill at McLean Lake was completed about a year ago. Ore previously mined from the JEB pit has been stored and will be fed into the new mill as soon as an operating licence is obtained. COGEMA has applied for that licence which will receive initial consideration by the Board at its April 22 meeting and, following the Board's three meeting rule, a final decision will be made at the June meeting.

Record pouring of reactor walls at Qinshan 2

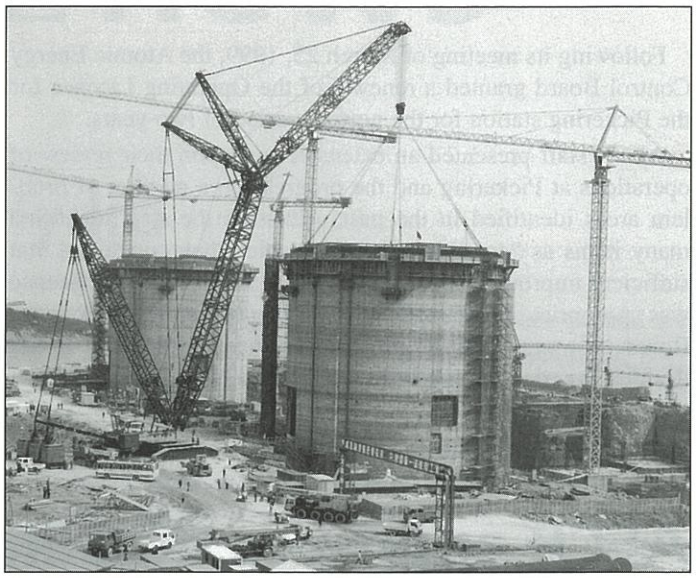
In February the reactor building walls of unit 2 at the Qinshan site in China were completed in a record time of 14 days and four hours from the start of slipforming. This is a record pouring time for CANDU 6 units. The building of first Qinshan unit was poured in October 1998 in a time of just under 18 days. For the four units in Korea, it took 21 days for the Wolsong 1 building back in 1983, 21 days and 9 hours for Wolsong 2; 20 days and 20 hours for Wolsong 3; and 17 days and 11 hours for Wolsong 4.

Involved in this achievement were the Chinese construction contractors, Huxing and CNI #22, along with the site staff of Atomic Energy of Canada Limited, with support from Canatom-NPM, project owner, Third Qinshan Nuclear Power Company, and staff back in Canada.

The reactor building wall is 42.3 metres tall and contains 6550 cubic metres of concrete. During the process the concrete was poured at a rate to increase the height an average of almost 5 inches an hour.

The Qinshan project is now into its third year, having been officially started on February 12, 1997.

Just as this issue of the CNS Bulletin was going to press AECL announced that the first calandria for the Qinshan reactors had been shipped from ALSTOM Canada Inc.in Tracy, Québec.



A view of the Qinshan project in China taken in late March 1999 showing the two reactor buildings with Hangzhou Bay in the background. *photo courtesy of AECL*

20th Anniversary of TMI

March 28 was the twentieth anniversary of the accident at unit 2 of the Three Mile Island nuclear power station in Pennsylvania, USA. The birthday resulted in several long articles in various print media but little other response.

As a reminder, the event at TMI 2 began in the early hours of March 28, 1979 when two secondary side, feed water pumps, stopped operating, attributed to water leakage into the air operators of valves on the polisher. The absence of circulation in the secondary side caused the temperature and pressure of the primary side to rise and a pressure relief valve opened. This caused a reactor trip. Although pressure in the primary circuit fell, the pressure relief valve failed to close but the signal in the control indicated that it had. Three emergency feedwater pumps began operating but the valves in their lines were closed. (All of this happened in the first minute.)

The steam generators boiled dry, and with no heat removal, the temperature and pressure of the primary circuit rose again. Two high pressure injection pumps began pumping water into the primary system. With the primary system temperature now remaining constant, the operators shut down one of the injection pumps. They still did not recognize that coolant was being lost from the open pressure relief valve.

The reactor building sump began filling with water, and the temperature and pressure of the building started to rise The pumps in the primary circuit began to vibrate (determined later to be caused by the mixture of steam and water in the system). Two of the primary pumps were shut down.

About 2 _ hours after the beginning of the incident it was recognized that the valve on the pressure relief valve was open and it was closed. However, as was determined later, about 2/3 of the core was now uncovered.

Six hours later a bubble of hydrogen in the containment building, that had been generated by a zirconium - steam reaction, ignited. After another two hours the attempt to reduce the pressure in the reactor was abandoned. Water levels rose and the core was covered.

A month later convection cooling was established and the plant was put into "cold shutdown" state.

It took nearly twelve years to clean up the badly damaged plant at a cost of almost one billion dollars.

Radiation releases from the plant were minimal. The average dose to people within ten miles of the plant was estimated to be 8 millirem with a maximum of less than 100. The state of Pennsylvania maintained a special registry of over 30,000 people who lived within five miles of TMI but closed it in 1997 without uncovering any unusual health trends. However, the accident caused much public concern fuelled by exaggerated media reports.

The Atomic Energy Control Board, like nuclear regulatory agencies in many countries, required Canadian nuclear reactor designers and operators to review the TMI accident and report on the significance to Canadian reactors. Little direct application to CANDU reactors was uncovered. Because the severity of the accident had been compounded by inappropriate operator action, TMI began the international interest in "safety culture".

COG Incorporates and Moves Offices

By the end of April 1999, the CANDU Owners Group (COG) will be incorporated as a Not-for- Profit corporation, under federal law, and be underway in its move to it's own offices at 480 University Avenue, Toronto.

In October 1998, Ontario Hydro indicated that they were not prepared to ratify the COG Member Agreement, due to concerns with various aspects of the then current situation. In particular Ontario Hydro recommended the setting up of a CANDU Owners Group after the style of similar Owner's groups in the U.S. and excluding AECL. The considerable dialogue which ensued from this, culminated in the hiring of a consultant to review the situation and make recommendations on a new framework.

This review was completed the same month and a report tabled with recommendations for restructuring. A large number of recommendations were made covering the areas of:

- Administrative/Legal Structure
- Membership
- Voting Rights
- Funding
- Program Management
- Contracting Procedures
- Program Areas/Activities
- Effectiveness of Member Support, and
- Transition Issues

The principal recommendations were broadly as follows:

- COG should be incorporated, a Board of Directors nominated and a full time (independent) President hired.
- Membership would be open to utilities owning or operating a CANDU plant and AECL as a vendor and architect/engineer.
- Membership would be two tier (Non Voting and Voting) so as to maximize membership of offshore utilities.
- Funding of specific projects (R&D and other) would be optional and on a pro-rata basis based on operating units.
- AECL's funding share would be dependent on the resolution of Proprietary Rights issues (i.e., COG Inc. should be reimbursed for proprietary information that flows to offshore utilities either directly or indirectly).

In addition many recommendations were made to increase the effectiveness of COG Inc.'s Project Management and Contracting procedures and to ensure that COG practices are consistent with good business/commercial practices.

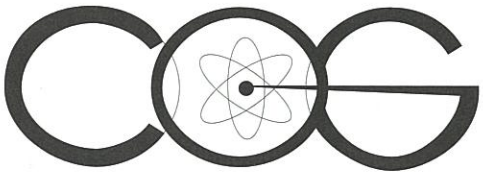
In general, the recommendations made were endorsed by the Members of COG and a program initiated to implement these recommendations.

During the first few months of 1999 a great deal of work was done establishing the framework for the new corporation as well as setting up the infrastructure of the new office facilities. A program of revising COG Inc. Policies and Procedures is ongoing and the first meeting of the new Board of Directors is expected on April 30th. The search for a new full time President has been initiated. *(See advertisement in this issue of the CNS Bulletin.)*

Changes to the way in which COG Inc. expects to conduct business will be communicated and explained to member organizations, contractors and particularly offshore utilities in the near future.

Anyone wishing more specific information or detail with respect to these changes should contact John Sommerville at CANDU Owners Group Inc., 480 University Avenue, Suite 200, Toronto, Ontario, M5G 1V2, (416) 595-1888 ext. 100.

Ed. Note: *We thank John Sommerville for sharing this information with readers of the CNS Bulletin.)*



CANDU OWNERS GROUP

The members of the CANDU Owners Group would like to solicit expressions of interest from suitably qualified candidates for the position of President of the CANDU Owners Group Inc.

A brief description of the Position and Qualifications follows.

Application should be made in writing prior to May 15 1999, addressed to:

CANDU Owners Group Inc.
c/o John D. Sommerville
480 University Avenue, Suite 200
Toronto, Ontario
M5G 1V2

THE POSITION

The CANDU Owners Group was formed in mid 1984 by the Canadian CANDU nuclear utilities and Atomic Energy of Canada Ltd. The group is now in the process of being transformed into a separate incorporated entity, the CANDU Owners Group Inc., which will have as members both on shore and off shore utilities owning & operating CANDU stations as well as AECL.

The broad mandate of COG Inc. is to provide a framework that will promote closer co-operation among the utilities owning and operating CANDU stations in matters relating to plant operation and maintenance and to foster co-operative development programs leading to improved plant performance.

The COG Inc. will be managed by a Board of Directors comprised of senior representatives of the member organizations. The initial member organizations are Ontario Hydro, Atomic Energy of Canada Ltd., Hydro Quebec and New Brunswick Power Corporation.

The President of COG Inc. will report to the Board of Directors and will be responsible for the day to day administration and direction of the group as well as providing a long term vision for organizational initiatives consistent with COG Inc.'s overall mandate.

The staff of the COG Inc. will comprise in the vicinity of 20 to 25 permanent positions either seconded from member organizations or contracted directly by COG Inc. Temporary staff positions may fluctuate significantly depending on the extent of project/program management being undertaken by the group.

The overall annual program budget is in the region of $20 to $25M with a general operating budget of around $2.5M.

THE CANDIDATE

The candidate for President of the CANDU Owners Group Inc. will have had extensive exposure to the management, operation and maintenance aspects of CANDU nuclear facilities. Such exposure would ideally include some degree of familiarity with areas such as:

Nuclear regulatory affairs
Public and media relations
Research and development issues
Safety and licensing
International co-operation in nuclear related issues

Above all, the candidate will have the business skills necessary to ensure that the CANDU Owners Group Inc. is operated according to sound business practices.

Familiarity with the unique challenges in managing and operating off shore CANDU facilities under foreign regulation and different socio-economic conditions would be beneficial.

QUALIFICATIONS

The ideal candidate must be able to develop and promote a vision for the CANDU Owners Group which will meet the changing and often disparate requirements of the members while enhancing the overall safety and economics of CANDU stations.

The candidate will have a degree in science or engineering and ideally possess an advanced degree in business administration or have sufficient alternate business related experience at a senior management level.

Preference will be given to candidates who are not employees of any of the member organisations of the CANDU Owners Group, although such candidates will be considered assuming acceptable secondment terms can be negotiated.

REMUNERATION

The appointment will be a contract position with the CANDU Owners Group Inc.. Salary and additional living expenses to compensate for work in the Toronto area will be negotiable.

If the position is filled by secondment from one of the member organisations the salary and expenses will be agreed directly between the incumbent and the member organisation.

Ontario Power Generation Inc. - Nuclear

With the breakup of Ontario Hydro as of April 1, 1999, the entity that has been known as Ontario Hydro Nuclear is now part of Ontario Power Generation Inc.

Following are organizations of the senior levels of OPG Inc. and the most recent one for the Nuclear Management Team.

OPG Organization

Chairman	William Farlinger
President and CEO	**Ron Osborne**
E.V.P. Chief Information Officer	John Mather
E.V.P. Chief Financial Officer	Wayne Bingham
E.V.P. Chief Nuclear Officer	Carl Andognini
E.V.P. Law and Corporate Development	David Drinkwater
S.V.P. Special Projects	Barry Nicol
S.V.P. Human resources	Chuck Gyles
S.V.P. Corporate and Environmental Affairs, Corporate Secretary	Richard Dicerni
General Auditor	Bruce Bennett
V.P. Year 2000 Project	Ted Clark
Ontario Power Technologies	(Vacant)

OPG Nuclear Management Team

G. Carl Andognini	**Executive Vice-President & Chief Nuclear Officer**
Carol Osler	Director Nuclear Security
Lana Saltsman	Executive Assistant
Carolyn Stock	Ombudsman
Joan Murphy	Senior Adviser - Nuclear Governance
Rick Machon	Nuclear Chief Operating Officer
Robert Nixon	Site V.P. - Bruce
Charles Packer	Site V.P. - Darlington
Gene Preston	Sr. V.P. NAOP & Pickering
Gene Preston	Senior V.P. NAOP & Pickering
Bob Strickert	Site V.P. - Pickering
Bob Ferguson	V.P. Workforce Planning
Brian McGee	V.P. Integrated Improvement Plan
David Kwan	Project Manager - Y2K
Roland Boucher	Project Manager - Pickering 1 - 4
Warren Peabody	Senior V.P. Technical & Chief Nuclear Engineer
Pierre Charlebois	V.P. Station Engineering Support
Paul Spekkens	V.P. Technical Support
John Skears	Director Eng. Stds. & Tech.
(TBA)	Director Station Proj. & Prog.
(TBA)	Senior V.P. Support
Bob Morrison	V.P. Managed Systems
Ken Nash	V.P. Waste Management
Larry Durham	V.P. Trng. Support & Services (Acting)
Brian Debs	V.P. Employee Services Mentor
Linda McRae	V.P. Employee Services
Ron Oberth	Project Manager - BASS
Donna McFarlane	Director Public Affairs
Dev Chopra	V.P. Finance
Brian MacTavish	V.P. Regulatory Affairs
Paul Young	Director Performance Assurance

Demonstration FOR nuclear

A Pro-Nuclear demonstration took place in Bonn, the capital of Germany, on March 9, reports "Nuclear Europe Worldscan", the journal of the Europan Nuclear Society.

According to NEW, about 35,000 people took to the streets of Boon to demonstrate against the German's government's plan to phase out nuclear power. The rally was organized by the union which represents most of the workers at German nuclear power plants.

Subsequently, the German economics minister, Werner Müller, is reported to have stated that there would be no "forced closures" of nuclear power plants within the lifetime of the current government. However, discussions between the government and the power companies have not led to any resolution of the issue.

Meeting on Nuclear Policy

A meeting will be held in Ottawa in September 1999 will focus on the past and future government policies related to nuclear energy.

The Conference on the Future of Nuclear Energy in Canada will be held in Ottawa, September 30 and October 1 at the Sheraton Hotel. It is being organized by Bob Morrison, former director-general nuclear and uranium, Natural Resource Canada, and Bruce Doern of Carleton University, under the auspices of the Carleton Research Unit on Innovation, Science and Environment (CRUISE).

The conference is arranged in four sections: International Context; Canadian Context; Provincial and Regional context; Environmental Implications, with senior representatives from federal and provincial governments and from industry.

Further information can be obtained by contacting Morrison at his e-mail address: < rmorrison@cyberus.ca >

A "Wake" for the U of T SLOWPOKE

Ed. Note: *The University of Toronto has decided to decommission its SLOWPOKE reactor and, reportedly, it was decreed last fall that the facility would not supply any analytical services after the end of 1998 and that the decommissioning would be completed by the fall of 1999. To mark the passing of this 27 year old facility, which has been the source of much research which led to many awards, such as that to Dr. R. E. Jervis by the American Nuclear Society last November, those currently involved, primarily (former) director, Dr. Ron Hancock and associate Dr. Susan Aufreiter, organized a "Wake" (in the Irish meaning of the word) on December 9, 1998. Since your editor was unable to attend the following account is based on information provided by Ron Hancock.*

(This report was supposed to be in the previous issue of the CNS Bulletin, but, somehow, was overlooked in the final layout process. Our apologies to all involved.)

More than 100 people, all of whom had been associated with the University of Toronto SLOWPOKE reactor sometime over its 27 year life, joined in a gathering which organizer Dr. Ron Hancock described as a "wake", on the afternoon of December 9, 1998. (Some had attended a lecture by Dr. Stan Hatcher on Nuclear Power in the Next Century presented immediately before the event.)

They crammed into the available space, with noise levels often exceeding provincial guidelines. Food and libations were provided by the SLOWPOKE Reactor Committee and only the coffee machine did not work. Susan Aufreiter and Ron Hancock welcomed new arrivals and Larry Pavlish (Physics) was the barman extrordinaire.

The organizers' rationale was expressed this way. Over the past 27 years at the SLOWPOKE Reactor Facility (SLOWPOKE-Toronto), faculty members and students have conducted their research one at a time, with little collective interaction. "Waking SLOWPOKE" (stolen from the must-see movie "Waking Ned Devine") was a great way to get all sorts of people together, to make something positive out of the death of a valuable, analytical, research facility.

Somewhere early in the afternoon, Les Bennett MCed brief speeches by John Hilborn, Bob Jervis, Ron Kay, and George Burbidge, and farewell gifts were presented to Susan Aufreiter and Ron Hancock. This did not slow the festive air of the afternoon one iota, and was greatly appreciated by the recipients.

Those present included:

The three inventors of SLOWPOKE-1 (John Hilborn, Ron Kay and Peter Stevens-Guille - all formerly of AECL-CRNL; before it changed to CRL);

Members of early SLOWPOKE Reactor Committees (Bob Jervis - who brought SLOWPOKE-1 to Toronto, Ken McNeill, Bill Paul, Joan Harrison);

George Burbidge (Nordion International Inc., formerly AECL Commercial Products, now MDS Nordion)) who loyally and competently maintained SLOWPOKE-2 for over 20 years;

People from afar (Amares Chatt, Dalhousie SLOWPOKE - the first Ph.D. from SLOWPOKE-Toronto; Jean-Francois Moreau, U.Q.A.C.; Greg Kennedy, Ecole Polytechnique SLOWPOKE; Les Bennett and Cathy Nielsen, R.M.C. SLOWPOKE);

Phil Stark (Aptec Engineering), who sold SLOWPOKE-Toronto the first multichannel analyser to begin INAA; Keith Thompson (Canberra-Packard), who sold SLOWPOKE-Toronto the Canberra series 80 system that served the Geological research community faithfully for 15 years; Craig Stuart (Becquerel Laboratories) who was a major industrial user on the 80's;

Faculty, staff and students came from Anthropology, Botany, Chemical Engineering and Applied Chemistry, Geography, Geology, Metallurgy and Materials Science, and Physics, at U of T; from McMaster University; from Mount Sinai Hospital; from the Hospital for Sick Children; from the Royal Ontario Museum; and from provincial and federal laboratories;

Norm Rubin (Energy Probe) was there to help wake SLOWPOKE and two people came on crutches. What more can one ask?

Graduate student, Chris Rancourt, has just finished his last analyses, as has Andrew McMinn, the last undergraduate researcher.

Postscript:

In reply to an inquiry from the CNS Bulletin on the rationale for closing the U of T SLOWPOKE, Dr. Peter Munsche, assistant vice-president, Technology Transfer, University of Toronto, wrote:

The reactor's core, installed in 1976, is approaching the end of its life. With the present core, the facility would not be able to maintain normal operation beyond 1999. A decision concerning the future of the facility was required since faculty and students planning their courses and research projects needed to know whether they would be able to use the reactor in 2000 and beyond.

In May 1996 an Advisory Committee was appointed to examine all of the available options and recommend a course of action. Two options were available, replace the core or decommission the reactor, both of which would be costly. Also in 1996, NSERC [National Science and Engineering Research Council] withdrew its infrastructure grant and turned down a request by the University for a Major Installation Grant to replace the reactor's core.

In January 1997 the Advisory Committee reluctantly concluded that the University should initiate decommissioning of the Slowpoke Reactor Facility beginning January 1, 2000. It is regrettable, as the facility has been a valuable resource for university research and teaching.

Dr. Hancock reported that there had been an offer of $500.000 towards the estimated $ 1 million cost of a new core but it was rejected and that a business plan that predicted SLOWPOKE could be operationally self-sufficient within five years was also not accepted.

CNS news

CNS to hold conference on nuclear energy and climate change

A CNS sponsored Symposium on Nuclear Energy and Climate Change will be held in Ottawa, November 17 to 19, 1999.

The objective of the two day event (Nov. 18 and 19) is to emphasize the benefits of nuclear energy technology as part of an integrated energy solution to reduce emissions of greenhouse gases in the world. A reception is planned for the evening of Nov. 17.

The program is being organized to have three sessions of invited papers, as follows:

- **Kyoto Protocol and energy technologies of the future**

Covering, the Kyoto Protocol, climate change contributed by greenhouse gas emissions from fossil fuels, the process initiated by the Climate Change Secretariat, the implication of Canadian's commitment to Kyoto Protocol, and vision of Canada's long term energy need.

- **Energy options to meet Kyoto Protocol and beyond**

Dealing with nuclear energy and other energy options, and supporting technologies, that will reduce greenhouse gas emissions to meet Canada's commitments to Kyoto Protocol. This includes nuclear energy and its applications for electricity generation, heating, desalination, production of hydrogen for transportation and other applications, extraction of oil from tarsands, food processing, for manufacturing, etc. Other energy options such as solar, wind, hydroelectric, and overall economic comparison and practical considerations of energy options will also be discussed.

- **Protection of the Environment**

This session will examine the demand for energy systems which, in the next few decades, will be driven by China, India, Indonesia and Brazil, and how the developed countries can help these countries to reduce GHG emission, and include a discussion on international cooperation, financing strategy (e.g. use of clean or flexible development mechanisms, etc).. The current safety record of CANDU, and programs for plant life management, long-term waste management, new CANDU designs with improved safety and economic performance, utilization of CANDU's flexible fuel cycle, and symbiosis between CANDU and the need in the major developing countries will be noted. A comparison of the cost of energy production from various options will be included.

The meeting is being organized by a team coordinated by Duane Pendergast of AECL Sheridan Park.

CNS President on Road to Recovery

Paul Thompson

As noted in the last issue of the CNS Bulletin, CNS President Paul Thompson suffered severe injuries on December 8, 1998, when the car he was driving was hit, head on, by one travelling the wrong way on a divided highway. He suffered a broken neck, two broken legs and a broken wrist. For three months he had pins and a brace on one of his legs and he wore a "halo" structure to immobilize his neck.

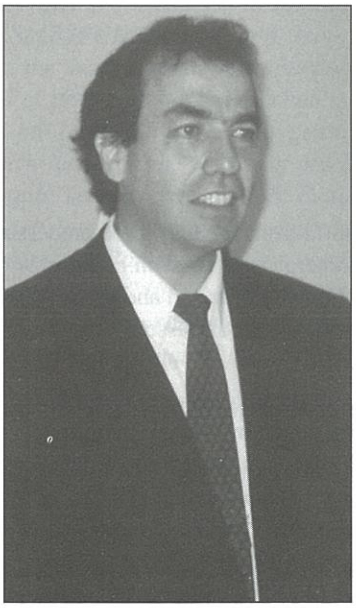
Paul was allowed to go home in mid February, but still wearing the brace and "halo". The latter was actually screwed to his head to prevent any movement. In early March his neck had improved sufficiently that the "halo" was removed, which Paul described as painful experience. He was fitted with a collar to limit motion of his neck. Then the brace was taken off his left leg and replaced with a heavy cast. The right foot had been in a cast all along.

At the end of March his right foot was fitted with a boot cast which Paul says looks like a fancy ski boot. Unfortunately the left leg has not been healing as well as desired. On April 8 he had an operation in which a piece of bone from his hip was grafted onto his left tibia bone.

The last information received, as this issue of the Bulletin was going to press in mid April was that Paul was practising standing up, putting weight on his right leg, and sitting down "in a controlled fashion". He reported that he was even able to operate the BBQ on the deck of his home in suburban Saint John, New Brunswick.

Ed. Note: *We are sure that all who know him, in fact all of the readers of the Bulletin, wish Paul continued good progress and hope to see him at the CNA/CNS Annual Conference in June.*

Obituary



William I. Midvidy

It is with great sadness that we note the passing of a founding member of the CNS, William (Bill) Midvidy, on March 1 1999 after a courageous two-year battle with cancer.

Bill earned his B.Eng. from Concordia and was awarded a M.C. and Ph.D. in Engineering from Carnegie-Mellon in 1972. In 1974 he was admitted to the Association of Professional Engineers of Ontario. Bill devoted his entire career to furthering the advancement of nuclear technology in Canada both through his work and his involvement with the Canadian Nuclear Society.

Bill pursued post doctorate studies at McMaster University prior to joining Westinghouse Canada in 1974. While at Westinghouse he was involved in experimental research and analysis of two-phase flow phenomena. In 1977 he joined Ontario Hydro. At Ontario Hydro he was involved in both experimental analysis and model development directly applicable to the safety and licensing of CANDU nuclear generating stations. Notable contributions have been in development of the Channel Cooling in the Absence of Forced Flow (CCAFF) methodology, his work on the MODTURC code used to calculate moderator temperatures required for assessing fuel channel integrity for large Loss of Coolant Accident analysis and the development of pressure drop and Critical Heat Flux correlations. All Bill's activities have contributed greatly to the improved understanding associated with a number of generic licensing issues relating to CANDU reactors in Canada. Bill has over 15 publications and has made several formal presentations at domestic and international conferences.

Bill's experience can be assessed by his involvement as an Ontario Hydro representative in the CANDU Owners Group since the mid 1970's. Until recently, he served on several Working Parties. These include Safety Thermalhydraulics, Critical Channel Power and Moderator Circulation. He served not only as a contributing member but also as a contract officer executing specific research programs and as Working Party Chairperson. His experience, insight and judgement were respected by all who have been involved in these Working Parties.

Bill was a member of the CNS since its inception. Despite a busy and demanding work schedule he devoted many hours of his own time to promoting and building the CNS. He served as Chairperson of the Nuclear Science and Engineering Division, Chairman of the Program Committee, was a founding member of the Honours and Awards Committee and has been on the organizing committees for many CNS conferences where he has served in the capacity of co-chairperson on several occasions. In 1992/93 Bill served as President of the CNS.

Bill has devoted the best part of his adult life serving the Canadian nuclear industry. He has been involved in the grass roots research, analysis and the development of models, and the management of research programs dedicated to making CANDU safer and more economic. These achievements were recognized in his being named a Fellow of the Canadian Nuclear Society in 1997.

Despite all of these career achievements, Bill was first and foremost devoted to his family, whose happiness and well being were both his #1 goal and his greatest success.

In 1997, Bill was diagnosed with brain cancer. Bill was determined to fight this disease with the same tenacity and energy that he had brought to bear in his professional activities. Such was his devotion to his vocation that for nearly a year, while undergoing radiation and regular chemotherapy treatments, Bill continued his duties at Ontario Hydro, as Head of the Experiments and Analysis Section of the Reactor Safety and Operational Analysis Department in Ontario Hydro, supervising the activities of 15 professional staff. A recurrence of the cancer forced a cessation of his duties in June 1998; but even then, he continued fighting the disease, agreeing to try several leading edge investigational drugs in addition to conventional treatments.

The Canadian Nuclear Society extends its heartfelt condolences to Bill's wife Rebecca and sons Daniel and Eric.

Ed. Note: *We thank Marv Gold, a colleague of Bill's, for the above note.*

BRANCH ACTIVITIES

Ed. Note: *Not all of the CNS Branches have provided reports. Following is a digest of the information available at the time of printing. The name in parenthesis is the chairperson of the Branch.*

CHALK RIVER (Al Lane)

Allen Kilpatrick, president & CEO of Atomic Energy of Canada Limited, was the guest speaker at the first winter meeting on, February 1. He reviewed the current status of AECL's program and the prospects for the near future.

MANITOBA (Morgan Brown)

Although there were no activities to report for the first three months of the season discussions are underway with several potential speakers.

Pens, engraved with "The Manitoba Branch of the Canadian Nuclear Society", were purchased as a spur for the Branch members to send in their membership dues, a visible way of saying they have not been forgotten, and perhaps a prompt to think about Branch activities. People have often asked "What do we get for the membership fee?"

Last year the Branch chairman participated in the Manitoba Earth Day celebration in Winnipeg (with a CNS exhibit), but there doesn't seem to be a similar event this year.

NEW BRUNSWICK (Mark McIntyre)

(Mark submitted a long report which is just summarized here.)

On Jan 8, 1999 the New Brunswick Branch held a noon hour membership drive at the Point Lepreau Generating Station auditorium. The guest speaker for the event was Beverly Ecroyd, Senior Project Officer for the AECB at the Point Lepreau site. Overall the event gave CNS very good exposure. We immediately received four new members and several renewals. It is expected that a few other applications will be sent directly to the CNS office.

On February 9, Hop C. Howlett II gave a multimedia presentation on "Leadership" at the Saint John Regional Library. Hop is the author of *"The Industrial Operator's Handbook"*, and *"Managing People: The Art of Leadership"*. Hop worked as a unit commander of a bomb squad in Washington D.C. , and as a shift supervisor for reactor plant operations at the US DOE's Naval Reactors Facility.

On February 16, Mark Wright spoke to a CNS sponsored noontime gathering at Point Lepreau Nuclear Generating Station's STOIC auditorium. The lecture was titled "Nuclear Fusion: the Joint European Taurus (JET)". The JET is a collaborative effort amongst the European Community to study the feasibility of fusion power. Mark spent several years at the Abingdon, United Kingdom site working on many aspects of the Safety Report for the deuterium-tritium operation.

Plans are ongoing for the NB Branch 1999 Annual Dinner, traditionally held each spring.

OTTAWA (Sadok Guellouz)

Following its first meeting of the season on Nov. 12, 1998 with Jon Jennekens, former president of the AECB, as guest speaker, the Ottawa Branch held two more talks.

On January 14, Dr. Bob Morrison (former Director General of the Uranium and Nuclear Energy Branch at Natural Resources Canada) provided an overview of a report that he recently completed for NRCan. The report is titled *"Nuclear Energy Policy in Canada (1942 to 1997)"*. Dr. Morrison provided an interesting review of the federal government's involvement in the development of Canada's nuclear power program.

On February 25, 1999, Dr. Bill Buyers presented a talk entitled "Neutrons for the Next Fifty Years". Which was primarily on the proposed Canadian Neutron Facility (CNF).

Our next talk is scheduled for April 15 with Beth MacGillivray as guest speaker.

For the third consecutive year, the Branch is continuing its support the Regional Science Fair by offering a donation and a special CNS award (cash prize plus certificate) for nuclear related projects. Unfortunately, this year there were no projects that were at all suitable.

PICKERING (Marc Paiment)

Work by Ontario Hydro on the Information Centre auditorium is progressing. The Pickering Branch has asked Gordon Brooks to give the first talk in this new facility (date to be confirmed). His talk will be a repeat of the presentation on "The Evolution of CANDU Design and Technology", which was given at the U of T (see Toronto Branch report).

SASKATCHEWAN (Walter Keyes)

The pamphlet - "The Nuclear Advantage" (Saskatchewan Edition) - is being sent to every school in Saskatchewan, and is included in delegates kits for municipal and rural government bodies annual conventions, teachers conferences, members of provincial and federal parliaments as well as other bodies.

A high school essay contest for students from grade 10 - 12 is also being held to attract further interest and involvement in the subject matter in the pamphlets. Five essay topics are available for students to address. The material will go to each school and will be posted on our web site. We are looking at possibly posting the winning essays on our branch website.

On other matters, Dr. Ralph Cheesman has been asked to take over as Sask Branch Chair. A Branch meeting will be held soon to effect the change.

SHERIDAN PARK (P. Gulshani)

A number of meetings have been held or are planned.

On January 21, Clair Ripley (AECL New Brunswick) presented a seminar on "Programs to Enhance Public Support for Nuclear Energy". On February 18, Murray J. Stewart (CNA President) spoke on "Nuclear Power - Clean Sustainable

Energy". On March 25, R. Allan Brown described his work on "Safe Operating Envelope - The Invisible Boundary" , followed a few days later, March 29 with Michael Allen on "Structures on the Move" (1999 March 29).

The Sheridan Park Branch is planning to hold a CNS barbeque in early summer and to distribute one-page CNS calendars to CNS members at renewal time to increase membership. The branch is planning take high school students on a tour of Pickering in April/May, 1999

TORONTO (Adam McLean)

The Toronto Branch co-sponsored a seminar with the University of Toronto on January 13. Margaret Maxey of the University of Texas spoke on "Rad-Chem Risks: Visions in Collision". Mr. R.A. Brown gave a talk on "The Safe Operating Envelope - the Invisible Boundary" at a CNS meeting on February 3 in the Ontario Hydro auditorium. On March 2, the Branch co-sponsored a seminar with the Central Canada Branch of the Institute of Mechanical Engineers, at the University of Toronto. Gordon Brooks spoke on "The Evolution of CANDU Design and Technology", as part of the Engineering week program. Ben Rouben was instrumental in getting these seminars organized, or working out the co-sponsorship arrangement with the other organizations.

Early in March, a new Executive was formed for the Toronto Branch. The new Chair is Adam McLean, an engineering student at the University of Toronto. He has previously worked at AECL. Teruo Takahashi (of Marubeni Canada Ltd) is the new Vice-Chair. Andrew Lee will act as interim Treasurer. The first seminar organized by the new executive will take place on April 20 at the Ontario Hydro Auditorium. It will be a presentation by Murray J. Stewart (CNA President) on "Nuclear Power - Clean Sustainable Energy".

(Adam McLean is currently a third year student in Engineering Science. He reports that he began doing Science Fair projects on nuclear power at an early age In grade 10 he made it to the Canada Wide Science Fair and won a CNS sponsored scholarship which helped him begin his studies at university.)

Reactor Safety Course

Another successful Reactor Safety Course was presented by the Canadian Nuclear Society in March 1999 with over 40 participants. As for the past couple of courses this one was held at the Conference Centre at the Sheridan Park Research Community in Mississauga, Ontario. Most of the attendees were from AECL but there was representation from Babcock & Wilcox and from the Atomic Energy Control Board.

This course had been organized in a very short time because the Society had received a request from Atomic Energy of Canada Limited. Anca McGee stepped in, with no experience other than having been a student at an earlier course. With some guidance from Glenn Harvel she presented a very well run course.

Given the repeated demand for this course a further one is planned for next year.

Canadian Nuclear Society / Société Nucléaire Canadienne (inc.)

Proposed Slate for 1999/2000 Council

Executive:

V.S. Krishnan (Krish)	AECL	President (Automatic roll-over)
K.L. Smith (Ken)	UNECAN	1st Vice-President (President Elect)
D. Jackson (David)	McMaster U	2nd Vice-President
I. Wilson (Ian)	retired	Secretary
S.Y. Lee (Andrew)	Ontario Hydro	Treasurer
P.D. Thompson (Paul)	New Brunswick Power	Past President (Automatic)

Members-at-Large:

P. Gulshani (Parviz)	AECL	M. Rhéaume (Michel)	Hydro-Québec
G. Harvel (Glenn)	AECL	B. Rouben (Ben)	AECL
D.A. Jenkins (David)	AECL	A.W.L. Segel (Duke)	retired
P. Laughton (Peter)	AECL	J. Tamm (Judy)	AECL
K. Mohan (Kris)	AECL		
A. Pant (Aniket)	Zircatec Precision Industries	(M.J. Stewart	President,
J. Popovic (Jad)	AECL		Canadian Nuclear
E. Price (Ed)	AECL		Association Ex-officio)

News of Members

Shayne Smith, a former member of the CNS Council and one-time chairman of the Membership committee, has been General Manager of the Toronto Division and a Managing Director of the Wardrop Group of Companies. Shayne joined Wardrop in 1988 and was appointed Manager of Product and Machine Design in 1994. He was quite active in the committee to have the large ITER fusion reactor sited in Canada.

John Sommerville, former manager of the Point Lepreau nuclear generating station and startup manager for the Cernovoda 1 unit in Romania, has been engaged to help reorganize the CANDU Owners Group and has been temporarily located in Toronto for this task.

Hans Tammemagi, one time scientist with Atomic Energy of Canada Limited and now an independent environmental consultant and author, was featured on the "Enterprise" page of The Globe and Mail, on March 25, 1999. That page, and the article, concentrates on individual entrepreneurs.

Tammemagi conducts environmental audits, mostly on buildings for the federal government, and runs a business called Oakhill Publishing House through which he has published a number of books, including a popular travel guide he wrote, "Exploring Niagara". He has just completed, with support by the CNS, a popular-level text on nuclear energy which will be published by the University of Toronto Press this year.

New Members

We welcome the following new members who have joined the Canadian Nuclear Society since the last issue of the CNS Bulletin.

Zary Akhavan
Yoshiaki Ando
Robert B. Bateman
Abbes Bellil
Ralph Cheesman
Les Chrobak
Natalie Cubias
Greg Evans
Pierre Girouard
Jie Wei Gu
Jim Harvie
Chineb Hasnaoui
Hop C Howlett II
Olga Djurisic Jevremovic
Khaled Joober
Jean Koclas
Frances Lipsett
Neige J. Martin
Ovidiu Nainer
Nick Papadopoulos
T.K. Ramakrishnan
John A. L. Robertson
Allen Rosevear
Yang Qiang Ruan
John I. Saroudis
Paul Sermer
Erica J.M.Yetman

Don't let your CNS membership lapse!

Is your membership in good standing? If perchance you have forgotten to make your payment for 1999, please take a moment to do so now. You must act now to keep receiving the Bulletin and other CNS mailings!

Renewing is easy. You can do so by:

- calling Sam Cherid or Sylvie Caron at the CNS office (416-977-7620), or
- e-mailing them at cherids@cna.ca or carons@cna.ca, or
- printing and filling out an application form, included in this mailing. The form is also available on the CNS website at http://www.cns-snc.ca.

If you cannot remember whether you are paid up for 1999, you can quickly confirm your standing by communicating with Sam or Sylvie as above.

If you do not intend to renew, we would appreciate knowing what the CNS can do better to retain your interest.

Thank you!

Votre adhésion à la SNC a-t-elle expiré?

Êtes-vous encore membre en bonne et due forme? Si, par hasard, vous avez oublié de payer vos frais d'adhésion pour 1999, veuillez prendre un petit moment pour le faire. Vous devez renouveler sans délai pour continuer à recevoir le Bulletin et autre courrier de la SNC!

C'est très facile de renouveler. Vous pouvez soit:

- téléphoner à Sam Cherid ou à Sylvie Caron au bureau de la SNC (au 416-977-7620), soit
- communiquer avec eux par courrier électronique: cherids@cna.ca, carons@cna.ca, soit encore
- remplir un formulaire d'adhésion, que vous trouverez dans cette enveloppe. Le formulaire est également disponible au site web de la SNC (http://www.cns-snc.ca).

Vous ne vous souvenez pas si vous avez payé pour 1999? Sam ou Sylvie pourront vous informer.

Si vous ne comptez pas renouveler, nous aimerions savoir ce que la SNC devrait faire pour mieux retenir votre intérêt.

Merci bien!

"Introduction to Nuclear Reactor Kinetics"

by Daniel Rozon (Ecole Polytechnique)
Translated by Benjamin Rouben (AECL)
reviewed by Dr. Wm. Garland, McMaster University

Polytechnic International Press, Montreal, 1998,
ISBN 2-553-007000-0, C$ 78, US$ 54.

This is a new English translation (by Ben Rouben) of Daniel Rozon's 1992 book *"Introduction à la cinétique des réacteurs nucléaires."* The content is essentially unchanged from the original French version but the availability of the book in English should encourage its wider use.

The first three chapters provide the required background and set up the basic equations.

1. **Neutron-nucleus interactions and fission:** which includes explanations of various types of neutron-nucleus interactions, fission, production of neutrons and delayed neutron groups.
2. **Diffusion equation and the steady state:** which includes; neutron balance in a reactor, the diffusion equation, time-independent diffusion equation and the eigenvalue problem, perturbation theory and the adjoint flux
3. **Point-kinetics equations:** covers the general formulation of such equations, common formulations of the point-kinetics equations, point model and interpretation of the kinetics parameters, and integral formulation of the equations.

The remaining chapters examine various solutions to the kinetics equations including practical examples of interest to the CANDU.

4. **Elementary solutions** of the kinetics equations including initial steady state and source, response to reactivity step with a single group of delayed neutrons, generalization to several delayed-neutron groups, response to a unit neutron pulse and to changes in the external source
5. **Approximate Solutions** including ramps and periodic variations, approximations for the delayed-neutron source small-amplitude approximation (linearization), prompt-jump approximation, reactivity ramps and log-rate protection, prompt kinetics approximation, and periodic variations of reactivity
6. **Temperature and Void Feedback in CANDU:** thermal power and neutronic power, feedback effects, temperature reactivity coefficient, reactivity effect of voiding and calculation of fuel temperature.
7. **Numerical Solutions with Temperature Feedback:** numerical methods for point kinetics equations, temperature feedback effects on power in CANDU, implications for control and safety and prompt kinetics with feedback (Nordheim-Fuchs model).
8. **Space Time Kinetics:** general problem of reactor dynamics, energy-space time approaches, factorization methods, modal synthesis and neutronic coupling, and space-time effects.

In addition, there are two appendices of considerable practical interest:

A. Xenon and Samarium Effects in CANDU

B. The Chernobyl Accident

Overall this is an excellent monograph that can used be used as the basis for a senior undergraduate or graduate course in nuclear engineering. As one of the very few books in the field containing substantial material on CANDU, it is particularly welcome to the Canadian nuclear community.

Proceedings, International Symposium on Health Effects of Low Doses of Ionizing Radiation: Research Directions for the New Millennium

The *"International Symposium on Health Effects of Low Doses of Ionizing Radiation: Research Directions for the New Millennium"* which was held in Ottawa on June 8, 1998, drew a large attendance and considerable interest. As well as the various papers presented by internationally recognized experts, the **Proceedings** include a record of the concluding debate.

The Symposium Proceedings are now available. The cost per book is $38.00 plus $ 6,00 for shipping and handling. You can place your order by fax or by e-mail to:

PATRICIA CULLEN, Administrative Officer, Institute for Research on Environment & Economy, 5, Calixa-Lavallée, P.O. Box 450, STN A, Ottawa, Ontario K1N 6N5, FAX: (613) 562-5873; e-mail: < pcullen@uottawa.ca >

CALENDAR

1999

May 10 - 14

International Symposium on Environmental Protection at Facilities
contact: P. Thompson
AECB, Ottawa
Tel: 613-995-5116
e-mail: thompson.p@atomcon.go.ca

May 30 - June 2

CNA/CNS Annual Conference
Montreal, Quebec
contact: Sylvie Caron
CNA/CNS Office
Toronto, ON
Tel: 416-977-6152 ext. 18
Fax: 416-979-8356
e-mail: carons@cna.ca

May 31 - June 3

Annual Conference Canadian Radiation Protection Assoc.
Saskatoon, Saskatchewan
contact: Steve Webster
Univ. of Saskatchewan
Saskatoon, Sask.
Fax: 306-933-7775
e-mail:
steve.webster.lab@govmail.gov.sk.ca

June 6 - 10

ANS Summer Meeting
Boston, MA
contact: ANS Office
La Grange Park, Illinois
Tel: 708-579-8258
Special Session at ANS
- Industrial Applications of Neutron Scattering

contact: Aslam Lone
AECL Chalk River
Tel: 613-584-8811 ext. 5287
Fax: 613-584-8047
e-mail: lonea@aecl.ca

June 15 - 18

Effects of Low and Very Low Doses of Ionizing Radiation on Human Health
Toronto, Ontario
contact: Canadian Nuclear Workers Council
Toronto, Ontario
Tel: 416-481-4491
Fax: 416-481-7115

July 24 - 27

Science Teachers' Course
Fredericton, N.B.
contact: Clair Ripley
AECL - NB
e-mail: ripleyc@aecl.ca

Aug. 1 - 5

Symposium on Flow - Induced Vibration - 1999
Boston, Mass.
contact: Michael Pettigrew
AECL - CRL
Chalk River, ON
Tel: 613-584-8811 ext. 3792

Aug. 29 - Sept. 3

Global '99 - International Conference on Future Nuclear Systems
Jackson Hole, Wyoming
contact: Dr. Todd Allen
Argonne National Laboratory
P.O. Box 2528
Idaho Falls, Idaho
83403-2528
e-mail: todd.allen@anlw.anl.gov

Sept. 6 - 10

3rd International Conference on Isotopes
Vancouver
contact: Dr. Nigel Stevenson
TRIUMF
4004 Westbrook Mall
Vancouver, BC V6T 2A3
e-mail: nigel@triumf.ca

Sept. 12 - 16

Decomissioning, Decontamination and Reutilization
Knoxville, Tenn.
contact: John E. Gunning
e-mail: jegunnin@bechtel.com

Sept. 12 - 17

International Conference on Inertial Fusion Sciences and Applications
University Bordeaux, France
contact: IFSA '99
162, Avenue Dr. Schweitzer
33608 Pessac Cedex
France
e-mail: voirin@ixl.u-bordeaux.fr

Sept. 12 - 17

2nd Symposium on Technologically Enhanced Natural Radiation
Rio de Janeiro, Brazil
contact: Andrea Couto
CONGREX do Brasil Ltda.
e-mail: andrea@congrex.com.br

Sept. 12 - 17

6th International Conference on Facility Operations - Safeguards Interface
Jackson Hole, Wyoming, USA
contact: Steve Herring
P.O. Box 1625 MS 3860
Idaho Falls, Idaho
83415-3860 USA
web site: www-citr.ornl.gov/ans

Sept. 25 - 28

ICENES 2000: 10th International Conference on Emerging Nuclear Energy Systems
Petten, The Netherlands
contact: Dr. Harm Gruppelaar
Petten, The Netherlands
e-mail: gruppelaar@ecn.nl
website: www.ecn.nl

Sept. 26 - 29

6th International CANDU Fuel Conference
TBD
contact: Mukesh Tayal
AECL - SP
Tel: 905-823-9040 ext. 4652
e-mail: tayalm@aecl.ca

October 3 - 8

NURETH-9 - 9th International Meeting on Nuclear Reactor Thermalhydraulics
San Francisco, California, USA
contact: Dr. S. Levy
Levy & Associates
3880 South Beacon Avenue
Suite 112
San Jose, California
USA 95124

Nov. ?

CNS Simulation Symposium
Ottawa, ON
contact: Dr. G. Harvel
AECL-SP
Mississauga, ON
Tel: 905-823-9060 ext. 4543
e-mail: harvelg@aecl.ca

Nov. 14 - 18

ANS Winter Meeting
Long Beach, California
contact: ANS Office
La Grange Park, Illinois
Tel: 708-579-8258

Nov. 16 - 18

International Topical Meeting on Nuclear Plant Instrumentation, Control and Human-Machine Interface Technologies
(embedded in ANS Winter Meeting)
contact: Dr. R. M. Edwards
Unitersity Park, Penn., USA
Tel: 814-865-0037
Fax: 814-865-8499
e-mail: rmenu@engr.psu.edu

Nov. 17 - 19

Symposium on Nuclear Energy and Climate Change
Ottawa, Ontario
contact: Duane Pendergast
AECL - SP
Mississauga, Ontario
Tel: 905-823-9060 ext. 4582
e-mail: pendergastd@accl.ca

2000

March 19 - 24

6th International Conference on Tritium in Fission, Fusion and Isotopic Applications
Augusta, Georgia USA
contact: Faye M. Williams
Westinghouse Savannah
River Site
773 A
Aiken, S.C. 29808 USA
Fax: 803-725-2756

June ?

CNA / CNS Annual Conference
Saskatoon, Sask.
contact: Sylvie Caron
CNA/CNS office
144 Front St. W., Ste 475
Toronto, ON
e-mail: carons@cna.ca

Sept. 25 - 28

ICENES 2000: 10th International Conference on Emerging Nuclear Energy Systems
Petten, The Netherlands
contact: Dr. Harm Gruppelaar
Petten, The Netherlands
e-mail: gruppelaar@ecn.nl
website: www.ecn.nl

Oct. 15 - 19

12th Pacific Basin Nuclear Conference
Seoul, Korea
contact: Mr. Kyo-Sun Lee
KAIF
Seoul, Korea
Fax: +82-2-785-3975
e-mail: kaif@borna.dacoin.cc.kr

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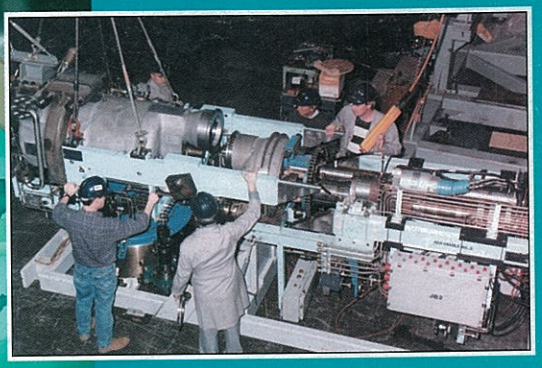

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